"Victory Bonds—Constructive Reconstruction"

CHEMICAL & METALLURGICAL ENGINEERING

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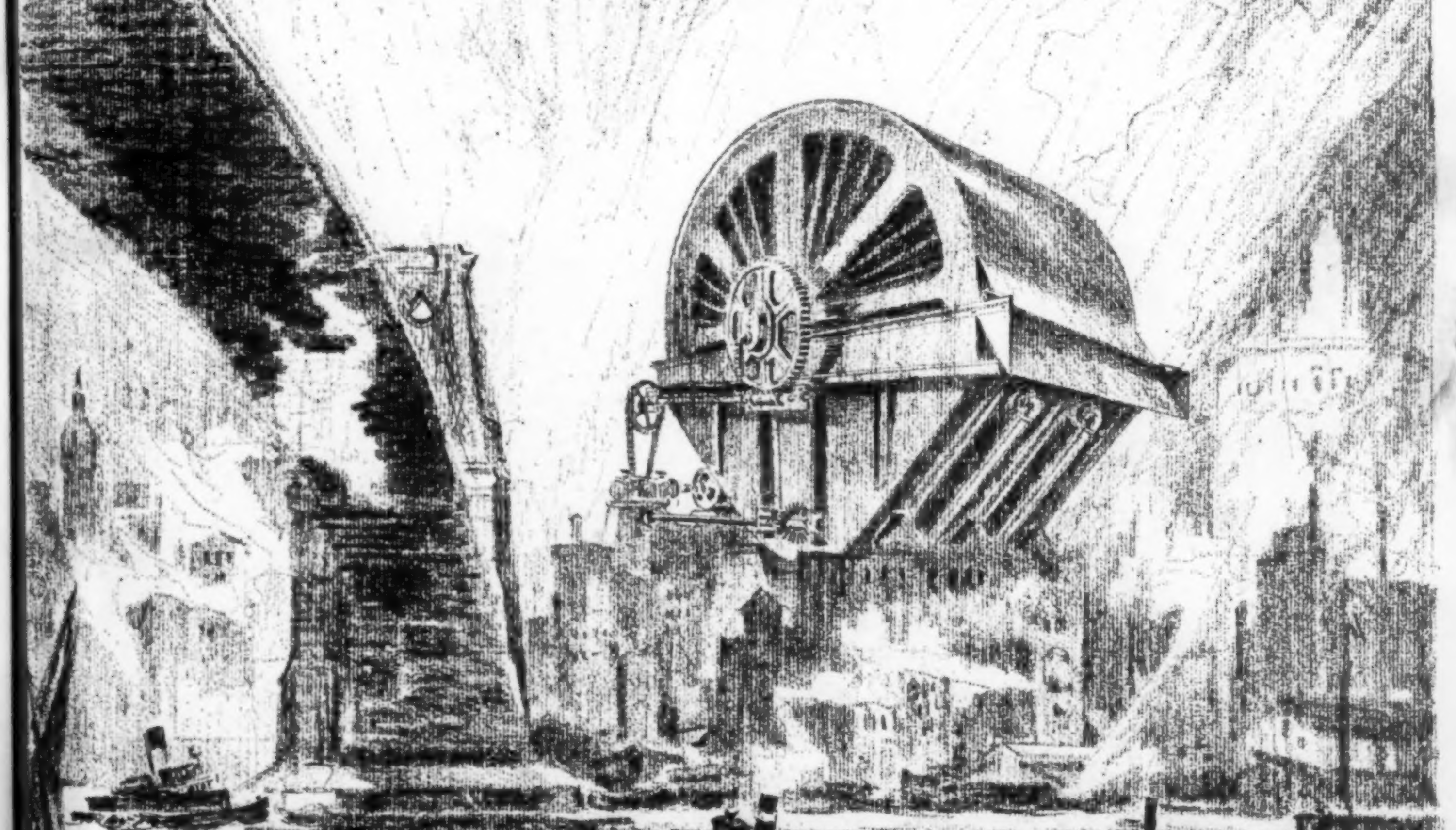

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Volume, XX, *Number* 7

Warning! Beware the Gas-Mask!

A WORD of caution—perhaps it should be repeated many times and in many places—is in order regarding the indiscriminate use of the Army gas-mask. These can readily be had, either from returning soldiers or from dealers—as apparently there is little to prevent a manufacturer from producing a replica for sale. Men from the other side have implicit confidence in them—this was drilled into them in the back areas and later became strengthened from their own observation in the fighting line; without a mask, a man was a casualty; with a mask, all manner of "hell pepper" couldn't touch him.

Naturally these men will now not hesitate to don a mask and rush into almost any smoke or fume filled room, sure of that adequate protection which is utterly lacking in many instances. The confidence so carefully built up in the Army must be dispelled in civil life, and anyone who cherishes a gas-mask against a time of emergency should be carefully warned as to its limitations.

It is not widely realized that the nervous system cannot detect a deficiency of oxygen. The remarkable sensibility to "close" or "stuffy" atmosphere is a reaction against excess carbon dioxide rather than against lack of oxygen. Thus a normal person gradually deprived of oxygen, either in a test chamber or by ascending to extremely high altitudes, does not realize that he is being gradually stifled by lack of that necessary element and he suddenly loses consciousness without any preliminary warnings.

Herein lies the danger of indiscriminate use of the Army gas-mask. It is a gas-filter, pure and simple, designed to remove from the air the generally minute percentages of excessively poisonous gases which characterize the modern battle area. But carefully note that nowhere, except in the immediate proximity of a shell-burst, is the amount of toxic gas sufficient in amount materially to reduce the actual amount of oxygen passing through the breathing apparatus and entering a man's lungs.

A little consideration immediately indicates how different are conditions in a burning structure, a smoke flue, or a gas-filled room. Here a large proportion of the oxygen has already been consumed and replaced by such gases as carbon monoxide, carbon dioxide, sulphur dioxide, methane or ammonia. Even though the canister-filling would remove such gases (which in general it will not), the amount of oxygen contained in a lungful of the resulting atmosphere is quite insufficient to maintain life, and the result is the speedy collapse of the unwary victim. To live in such places a man must evidently wear a mask or helmet of a radically different type, that is to say, one which generates oxygen within itself.

The foregoing should not be interpreted as meaning that the tremendous amount of labor and thought expended on our Army gas-masks will be lost to industry. Quite the contrary. There is no reason why proper absorbents cannot be used effectively to clear the many dangerous fumes and smokes occurring in work-a-day life—different absorbents evidently will be used for the wide variety of gases encountered. But take especial pains to emphasize to miners, firemen, chemical workers and smelter men that the good old gas-mask which took them safely through the Argonne is powerless to aid them against fire-damp, in burning buildings, gas chambers or furnace flues. It's not the fault of the mask—it can be loaded so as to filter out almost anything, but it cannot supply a lack of oxygen which a man does not miss until it is too late!

Nitro-Aromatics vs. Nitroglycerine

WHEN the armistice was declared the War Department had 50 million pounds of TNT in its possession. The Government had built and equipped numerous plants for the recovery and nitration of toluol and the manufacture of picric acid, and in general there had been a great expansion in the production of nitro-aromatics. For want of more intelligent disposal somebody proposed to dump the TNT into the sea; and with the end of the war vast and expensive plants were promptly closed. What is the prospect for reasonable salvage?

Here is a situation, the future of which should appeal to industrial chemists of vision—the application of nitro-aromatics in the explosives industry, adapting a war munition to purposes of peace. The economics of the matter, as a correspondent points out elsewhere in this issue, favor the development of nitro-aromatics as against continued reliance on nitroglycerine. The proposal will encounter prejudice and inertia, but we doubt if even the prejudiced would contend vigorously that "it can't be done." If private initiative is lacking, the subject would be suitable for investigation by a Government agency.

Research Forbidden to Railway Companies

WE shall not undertake to discuss the merits of the Government administration of railroads from the standpoint of transportation or investment. Every free-born American citizen is supposed to hold that he knows how to run a newspaper or a railroad; and whether he can or not, he is entitled to his own opinion as to the management and the service rendered. The former director-general of railway administration, the HON. WILLIAM G. MCADOO, invited everybody to write him freely, and say what he thought about his work and the manner in which he did it; and if this invitation has been generally heeded we should say that enough had already been written concerning the business management of the properties.

There is one feature, however, which in our estimation has not been adequately discussed, and that is the complete cessation of industrial research and of the development of natural resources of the territories served by the various railways. There has been a great deal of boasting over the "cutting down of unnecessary expenses," and if geological surveys and industrial departments are held to be "unnecessary expenses" we think it time to put a crimp upon the boasting.

There are many old and tried aphorisms which are sound in doctrine if intelligently applied; but when the same old saws are offered as excuses for doing the wrong thing they become about as vicious as German propaganda. The study of the resources along the line of a railroad is its first step in the recording of assets that may be made available. Sometimes it is a good while before such assets may be realized, but that is no reason why they should be neglected. We are reminded of certain successors to the late SIR WILLIAM PERKIN in the manufacture of dyes in England. They were intensely practical men. They had no time for such nonsense as intangible things. SIR WILLIAM'S extensive scientific library was not wanted. His arrangements with leading chemists in academic life were canceled. The chemists engaged in research were discharged. As long as they could keep good foremen in the works and were sure they had the right "formulas" they were satisfied. Then, before they knew it, they were being undersold with German goods in their home town, and in a few years more they were practically driven out of business.

This was not a distinctly British view that muddled the minds of those Englishmen to their undoing and the loss to their nation of a great industry. It was the same distorted view that is still all too popular in this country: the notion that anything that cannot be tagged with the dollar mark of so much cost and such and such a selling price is to be discarded because it involves unnecessary expense.

We do not profess to have valuable opinions about ton-mile costs, but we do claim to know something about raw materials. The railroads of the South, where an almost illimitable store of mineral treasure is to be found, were doing splendid work before the war by having the territories adjacent to their lines surveyed as to their natural resources. If this had not been done we should have been in more than one sore dilemma during the past four years. We regard it as no less than a national misfortune that work along this line should not only have been discontinued, but effectively prohibited, so far as the railways are concerned.

We thought the war had taught us the value of applied science in industry. It sometimes seems as if some of us had learned to repeat the slogan without understanding what it means.

An Appraisal of the American Potash Industry

AMERICAN potash producers are passing through worrisome times. Six months ago the cry arose from every hand, "Get us more potash." With the cessation of hostilities and cheap Alsatian salts in prospect, the fertilizer market is paralyzed. Barred from this most important outlet, some four months' output has heaped up, threatening to overwhelm the modest financial resources of many producers. Unquestionably this tonnage has largely been produced in good faith in response to the national need, and as such constitutes an informal obligation upon the Government that it be utilized without loss to the manufacturers or the consumers.

But what of the future? A continuance of the past inflated prices of fertilizer potash will pinch the consumer, raise the cost of many necessary farm products, and tend to maintain the high cost of commodities which is primarily responsible for the present commercial stagnation. Economically it is bad. Technically

it is indefensible; why should processes be perfected for more complete or cheaper extraction, or for the utilization of by-products, as long the sale of one portion will cover the cost of slipshod, wasteful and defective operation?

And so we wish to protest most emphatically against limitation of imports, a tariff "wall," paternalistic subsidy, or any like schemes of this sort to be vigorously pushed by interested persons, all of them making for high-priced potash. Lest we be damned as free traders out of pot, we hasten to give cordial support to the Tariff Commission and its underlying principle, popularized as the difference in cost, here and abroad. What we wish to emphasize right here, however, is that 75 per cent and more of our 1918 production was made by processes which can meet fair foreign competition, eliminating the bogey of "trade-war."

In 1918 natural brines produced 40,000 tons K_2O from plants aggregating double that capacity. Nebraska lakes alone yielded about 55 per cent of last year's output, at a cost estimated by us Nov. 15, 1917, at $40 per ton K_2O plus interest, amortization, profit and royalty. Figures of $110 per ton quoted by others must include large amortization allowances. Considering that the 1912-1914 price of German muriate f.o.b. American port was $65 per ton K_2O (even though it had been sold under trade-war conditions at a much lower price), it appears that the most important branch of our industry will need but a moderate tariff if coast-to-interior rail freights are established and the financial agreements are sound.

Our most promising immediate source of local supply lies in cement-kiln dust. It yielded but 1500 K_2O last year from installations rated at 3500 tons, yet if all cement plants would recover this product some 70,000 tons of K_2O would result. It is possible to build a plant to handle the gases and fine dust from a 1000-bbl. plant for $30,000, which by simple methods will collect 95 per cent of the volatilized potash. Such an installation has made potash at $50 per ton K_2O, which cost includes labor, power, repairs and renewals, interest and amortization, but does not include a proper and material credit for recovered slurry. Evidently here is an operation which can stand on its own feet. The failure of cement-makers to embark on potash recovery has been ascribed to the hesitation to make plant investments without more attractive returns, but the day will come when a cement kiln without its potash scrubbers will be as rare as a smelter without a dust chamber. Potash from iron blast-furnace dust also is a promising source, though possibly further in the future.

No industry should be permitted to maintain a high price for the benefit of an inconsiderable few of its own number and to the disadvantage of the consuming public, in the face of a low-priced international supply and an actual and prospective source of cheap substance at home.

Commodity Values and Construction Work

THE United States Government is engaged in an effort to bring about a resumption of construction activities in the country. This is a very progressive country and matters are so aligned that we are not busy unless we are engaged in a great deal of new construction. Our natural resources are so great and our labor is so efficient that nothing like all the labor is given employment if we are engaged simply in maintaining our facilities and producing the things that we currently consume. Also, we make so much money, such large profits, that we have in the normal year a great deal of new capital that must be invested or lie idle. New construction, therefore, is necessary if there is to be normal activity.

In the latter part of March the Industrial Board of the Department of Commerce, which is engaged in an effort to deflate war prices in the interest of stimulating construction work, reached an agreement with the iron and steel producers whereby certain reductions in prices were effected. The character and extent of the reductions, as well as of those which occurred last December, are referred to in the market report on iron and steel in this issue. Comparisons are frequently made with prices before the war, the favorite period being the ten years 1904 to 1913 inclusive. The investor may observe that prices at this writing compare with ten-year pre-war averages as shown below. Prices of the non-ferrous metals refer to the common brands, cents per pound at New York, while the steel price is a weighted average of the leading finished steel products, in cents per pound, Pittsburgh. The pre-war price is the ten-year average of quotations, 1904 to 1913.

	Pre-war	Present	Change Per Cent
Copper	15.36½	15.25	− 1
Spelter	5.84	6.52½	+12
Lead	4.64	5.20	+12
Aluminium	28.50	29.00	+ 2
Antimony	9.88	6.62½	−33
Steel	1.80	3.25	+81

Of the five non-ferrous metals cited three are higher than before the war, while two are lower. If one struck an average of the five there would be a net decline, but that would be misleading, since antimony is relatively unimportant. No one can ignore copper, however, which has experienced a complete deflation under a billion-pound stock on hand, which is some 600 million pounds in excess of normal stock.

Steel, however, is still nearly double its pre-war average. That is something very difficult to explain. The steel producers point out that labor is very high, and when reminded that rail mills are almost automatic, while the modern blast furnace is composed largely of "labor-saving" devices, they rejoin that it requires labor to mine the coking coal and the ore, to transport materials and to make the machinery which the furnaces and mills use. The argument is frequently received as conclusive, but when steel and the non-ferrous metals are set side by side it becomes very difficult to explain why the arguments that have been accepted to explain steel's 81 per cent excess over the pre-war average do not have some considerable application to the non-ferrous metals.

What is the investor going to do about it? The steel that sold at pre-war prices is sold. It is not available. The pre-war price is interesting only as it may possibly furnish a guide as to the course of the market in future, but if steel had to come down, why has it not done so? Being a construction material in particular, why has not the absence of any considerable amount of new construction in the past few months brought it down with a crash? The investor wants to know whether it will come down in future, whether he will save money by waiting. He also wants to know, and this is a point frequently overlooked, whether he would make money by investing, even if he could not save by waiting.

Readers' Views and Comments

Potash Recovery

To the Editor of Chemical & Metallurgical Engineering

SIR:—I desire to call your attention to two articles published in your issue of Sept. 26, 1918, during the Chemical Show, one by Dr. J. S. Grasty and one by Mr. Lynn Bradley.

Dr. Grasty, in his article, gives a table, on page 437, which he precedes by the following statement:

> Table V, showing the cost of producing pig iron, depending on the kind of ore used, and the estimated results in potash recovery and profits therefrom by the erection of a Cottrell electric precipitator at a 200-ton iron blast furnace, was prepared in collaboration with Mr. Lynn Bradley, chief engineer of the Research Corporation.

In Mr. Bradley's article, in the same issue, a table on page 459 is preceded by the following statement:

> The following table has been compiled to show the economic importance of these ores as a source of potash, the figures having been based on experience at several other furnaces as well as on the data obtained in connection with these particular ores and at various iron furnaces in the South. The table has been submitted to experienced blast-furnace operators for suggestions and criticisms.

I am attaching a table which, excepting for the last item, is an accurate reproduction of both of these tables, so that the figures obtained by each author may be compared. Dr. Grasty's figures are headed by the letter "G". Mr. Bradley's figures are headed by the letter "B".

It is quite evident that they both have started with the same coke and the same limestone, as their figures are identical for these two materials; that they both based their figures on the same Cambrian ore and on the same brown ore, as the analyses of the materials given by both of them are identical for both ores excepting that Dr. Grasty reports 6 per cent H_2O in the brown ore column, while Mr. Bradley reports 6 per cent of lime magnesia. The potash contained in the three ores is the same for both authors.

Based on exactly the same figures for No. 1 Cambrian ore and No. 3 brown ore, Mr. Bradley and Dr. Grasty arrive at different conclusions. While they both find the same total potash content per ton of iron for No. 1 ore, they arrive at different losses of potash in the slag and elsewhere for the same ore. Dr. Grasty deducts 20.96 lb. for the losses, while Mr. Bradley deducts 10.4 lb. Dr. Grasty, therefore, finds 78.54 lb. potash collectible, Mr. Bradley, 89.1 lb. from the same ore. In the No. 3 ore, the same sort of discrepancy exists. Dr. Grasty allows 23.46 lb. of potash for losses per ton of iron, while Mr. Bradley allows 14 lb. per ton of iron, so that Dr. Grasty, of course, figures 10.51 lb. of potash is collectible, while Mr. Bradley figures that 19.97 lb. of potash is collectible per ton of iron.

Dr. Grasty makes an estimate of return which shows that unless a furnace runs on No. 1 Cambrian ore, it can expect no net return from the potash collection. He estimates the annual operating cost of a precipitator at a 200-ton furnace at $165,000. Revenue from potash on a furnace running on No. 2 red ore and No. 3 brown ore is so small, according to Dr. Grasty's figures, that it could not possibly, even with a 40 per cent water-

	No. 1 Cambrian Ore		No. 2 Red Ore		No. 3 Brown Ore	
	G	B	G	B	G	B
Material cost, long ton	$5.00	....	$2.00	....	$3.50	....
Content silica, per cent	19.20	19.20	18.00	15.00	19.50	19.50
Content alumina, per cent	4.80	4.80	5.00	4.00	3.80	3.80
Lime—Magnesia	1.30	1.30	18.00	17.00	6% H_2O	6.00
Potash	1.80	1.80	0.20	0.20	0.20	0.20
Iron	49.80	49.80	34.00	36.00	42.00	42.00
Ore required for one long ton of iron, lb	4,398	4,398	6,365	6,039	5,212	5,212
Percentage of burden	46.07	46.07	50.93	54.35	46.87	46.87
Coke required for one ton of iron, lb	2,700	2,700	4,480	3,900	3,000	3,000
Percentage of burden	28.29	28.29	35.85	35.22	26.98	26.98
Dolomite required for one ton of iron, lb	2,448	2,448	1,652	1,159	2,909	2,909
Percentage of burden	25.64	25.64	13.22	10.43	26.15	25.15
Material cost per ton of iron coke	$10.80	....	$17.92	....	$12.00	....
Material cost per ton of iron-ore	$9.82	....	$5.68	....	$8.24	....
Stone (dolomite 90 lb, limestone 100 lb.)	$1.09	....	$0.74	....	$1.30	....
Total material cost for one ton of iron	$21.71	....	$24.34	....	$21.54	....
Furnace capacity in tons iron output per day	230	....	180	....	220	....
Total material cost per day	$4,993	....	$4,381	....	$4,739	....
Average value per ton of iron produced	$33.00	....	$31.50	....	$33.00	....
Gross value of output of iron per day	$7,590	....	$5,670	....	$7,260	....
Gross profit on iron output per day (labor, etc., not considered)	$2,597	....	$1,289	....	$2,521	....
Gross profit on iron output per year as above	$908,950	....	$451,150	....	$882,350	....
Total potash content of burden per ton iron, lb	99.50	99.50	34.43	29.57	33.97	33.97
Deduct for losses in slag and elsewhere	20.96	10.40	31.28	15.60	23.46	14.00
Potash remaining, unknown portion, collectible, lb	78.54	89.10	3.15	13.97	10.51	19.97
Gross value potash at present price $5 per unit—350 days = 1 yr. operations:						
Equal to 25 per cent water-soluble	$395,154	....	$12,403	....	$50,579	....
Equal to 35 per cent water-soluble	$553,216	....	$17,364	....	$70,811	....
Equal to 40 per cent water-soluble	$632,247	....	$19,844	....	$80,927	....
Estimated operating cost per annum	$165,000	....	$165,000	....	$165,000	....
Estimated net value potash per annum—present 25 per cent	$230,154	....	....	....	....	....
Estimated water-soluble 35 per cent	$388,216	....	....	....	....	....
Estimated water-soluble 40 per cent	$467,247	....	....	....	....	....
Slag volume per ton iron, lb	....	2,715	....	3,290	....	3,090
Total potash in gases per day (500 tons iron)	....	44,550	....	6,985	....	9,985
Total potash in gases per 350-day year	....	7,796	....	1,222	....	1,74
Assume 80 per cent recovery	....	6,237	....	978	....	1,40
Value per annum at $500 per ton K_2O	....	$3,118,500	....	$489,000	....	$703,00
Value per annum at $100 per ton K_2O	....	$623,700	....	$97,800	....	$140,60
Value per annum per 100 tons iron at $5 per ton	$316,123	$623,700	$9,922	$97,800	$40,463	$140,60
	Coke		Limestone		Dolomite	
	G	B	G	B	G	B
Material cost, long ton	......	......	$1.00	......	$1.00	......
Material cost, short ton	$8.00	......	......	......	......	......
Content silica, per cent	8.70	8.70	2.00	2.00	1.25	......
Content alumina, per cent	5.00	5.00	1.00	1.00	1.00	......
Lime—Magnesia, per cent	0.30	0.30	53.00	53.00	58.88	......
Potash, per cent	0.30	0.30	0.30	0.30	0.50	......
Iron, per cent	1.70	1.70	0.00	0.00	0.00	......

soluble collection, show any profits from the potash value at the extreme price of \$5 per unit.

Reducing this to a 100-ton basis, and comparing Dr. Grasty's figures for return at \$5 per unit of K_2O with Mr. Bradley's figures reduced to the same basis, there is a very great discrepancy to be found. Dr. Grasty finds the revenue to be \$316,123 per 100 tons of iron per annum, while Mr. Bradley finds a revenue of \$623,700. The latter figures are slightly less than twice the former figures. Starting with No. 2 ore, with very little difference in composition and having exactly the same potash content, Dr. Grasty finds a gross revenue of \$9,922 per hundred tons of iron per annum for the potash, while Mr. Bradley finds, for the same conditions, \$97,800 revenue. The latter figures are nearly ten times the former. For No. 3 brown ore, Dr. Grasty shows a revenue of \$40,463, while Mr. Bradley shows a revenue of \$140,600. The latter figures are nearly four times the former.

Since Dr. Grasty comments that his table was worked out in co-operation with Mr. Bradley, it is worth while finding out how these two authors, in two papers, came to such extremely different results. Mr. Bradley's figures for potash content for ores No. 2 and No. 3 compared with the losses that he allows for these two ores check with results obtained by us in actual electrical precipitation tests on a semi-commercial scale. The ratio between his loss and the total potash content is similar to the ratio we have found. I cannot understand Dr. Grasty's deduction in ore No. 2 of 31.28 lb. out of a total of 34.43 lb. Given the same operating conditions on all three ores, even if the slag volume varies, I cannot conceive of any reason why there should be such a tremendous difference. I believe that for the No. 2 and No. 3 ores, Mr. Bradley's figures of losses approximate the actual conditions. For No. 1 ore, I hardly believe that either the figures of Dr. Grasty or Mr. Bradley are correct. It is evident that there has been an assumption that the same percentage of slag would be potash for all three ores, the lean and the rich.

Tests made by us on ferromanganese furnaces indicated that when the ores are richer in potash, the greater is the amount of potash lost in the slag. I am, therefore, of the opinion that no such condition as indicated by Messrs. Grasty and Bradley exists in actual practice. Our tests, while not conclusive, have led us to believe that with a rich ore, such as shown in No. 1 Cambrian, there is a loss of about 50 per cent in normal blast-furnace operation of the potash, while the other 50 per cent is recoverable. I believe, however, that this loss can be cut down to 30 per cent by proper methods of treatment.

In connection with the costs, information obtained by us in running semi-commercial tests indicates that the cost of operating precipitators for a 200-ton blast furnace is nearer \$70,000 per year than \$165,000. Per hundred tons of iron per annum the chargeable expense to the potash collection would be about \$35,000. This would make the cleaning of gases on furnaces running on ores as poor as Nos. 2 and 3 a very profitable undertaking. For No. 2 ore, based on Mr. Bradley's figures of gross revenue, the net returns would be about \$62,000 per hundred tons of iron per annum, while on No. 3 ore the returns would be a little more than \$105,000 for the potash per hundred tons of iron per annum.

The days of \$5 per unit potash are about over. There will be a natural tendency to determine what might be the profits on a \$1 per unit basis. Our figures for operation are about \$42,000 a year for a 200-ton furnace when potash sells at \$1 per unit. This difference is due to the smaller royalty paid on the cheaper potash. At that rate, the operating expense per hundred tons of iron per annum is \$21,000. The practice is to run on ores running much higher in iron than No. 2 red ore, and the general practice is closer to the ores shown under column No. 3 brown ore. With potash selling at \$1 per unit, according to Mr. Bradley's figures for No. 3 brown ore, which I believe are correct, there will be a revenue of \$28,120 per hundred tons of iron per annum for the potash content in the dust recovered by electrical precipitation. This will yield a net revenue of over \$7,000 per hundred tons of iron per annum for the potash recovered. There are a number of furnaces, however, running on a much richer ore.

While we have not completed our examination and we cannot therefore make the following as a definite statement, our initial analyses show that a brown ore in the South is running about or close to 1¼ per cent of potash. This ore also runs over 47 per cent of iron.

It would seem from Dr. Grasty's figures that there are no potash values to yield a net revenue even at \$5 per unit from either the No. 2 or the No. 3 ore, while the revenue from the No. 1 ore is considerable. If the corrections as designated above were made, the No. 1 ore would yield a revenue about one-third less than shown in Dr. Grasty's figures.

I cannot understand, however, how these two authors drifted so far apart in their final conclusions when using practically the same original data and working in collaboration with each other. N. H. GELLERT.

Philadelphia, Penn.

An Example of Crystal Crushing

To the Editor of Chemical & Metallurgical Engineering

Sir:—In your issue of Jan. 15 on page 72 appears a short article on "An Example of Crystal Crushing," in which the author states his opinion that the gray or silky spot usually seen in the center of the otherwise crystalline fracture of a medium-carbon steel test-bar is due to the fact that "the crystals in the interior of the bar were crushed during the elongating of the bar before rupture." The gray spots mentioned have often been seen in tensile tests of good-quality rails in this laboratory and have been the subjects of microscopic examinations. These examinations have always shown that there was no greater crushing or distortion of the crystals in the metal that had the gray fracture than there was in the metal with the crystalline fracture. Since the gray spots were always seen only in steel that contained an appreciable amount of ferrite, while steel without ferrite had a purely crystalline fracture, and steel composed chiefly of ferrite had a fracture that was all gray or silky, the opinion was formed here that the gray part represented a slow separation through ferrite, while the crystalline part of the fracture repre-

sented the final instantaneous break through the cleavage planes of the pearlite.

This, of course, does not explain why the silky or supposedly ferrite fracture should occur only at the center of the bar, when the microstructure was found uniform throughout, as it usually was. A consideration of the effects of the reduction of area, however, which accompanies all elongation of test-bars, may explain this. When the test-bar is elongated the outer particles of metal move not only lengthwise, but also inward toward the central axis, and as the circumference of the bar contracts the outer particles must move past each other to permit this contraction. Thus near the surface of the bar the increase in length is partly taken up by a sidewise rearrangement of the particles, while at the center the contraction is practically nil and the elongation is effected more largely by straight lengthwise movement of the particles. For this reason the tensile strains at the center are such as might be expected to cause fracture of the ferrite, being the weaker constituent of the metal, while nearer the surface the inward flow of metal would prevent the ferrite from breaking. Finally the inner fracture would become so large that the outer metal, even though hardened by slipping, could no longer sustain the load, and it would then break suddenly through its cleavage planes, giving a crystalline fracture. In other words, the formation of the silky center with crystalline rim is considered analogous to that of the common cup fracture of soft steel, with its gray silky center and sloping sheared rim. This explanation is believed to be more reasonable than one based on an assumed central crushing, which is not actually observed to be any greater than the normal distortion of the metal near the surface of the fractured test-bar. GEORGE F. COMSTOCK.

Titanium Alloy Manufacturing Co.,
Niagara Falls, N. Y.

Future of the Potash Industry

To the Editor of Chemical & Metallurgical Engineering

SIR:—What of the future of the American potash industry? Certainly it has been shown that American resources are adequate to supply American demands. But will these be further developed, or will the potash monopoly be handed back to Germany? If the public —the Government—now that the international crisis is over, loses its interest in the domestic industry and surrenders the trade to the unrestricted hands of those who operate without regard to the public weal or American commercial independence, without sentiment, potash will be purchased where it can be obtained the cheapest. And German potash, if admitted without restrictions, will be the cheapest potash. German subsidies will see to that.

It is said that Germany, to meet her financial obligations, will be forced to place an export tax on such commodities as potash, which will operate to maintain a high price for German potash. It must be remembered, however, that before an export tax on potash can be paid, potash must be exported; and before it can be exported, it will have to be re-established in foreign markets. For its re-establishment a low price must be its first requisite. There seems to be no reason to believe that the policy of the potash industry of Germany and the Government, with which German industry is closely allied, which prompted them to spend millions in potash propaganda abroad, will be reversed. It would appear that its exportation would now be of even greater importance than ever before.

The late military war was won by science, organization and efficiency. It was demonstrated that without these the man power combined with the wealth of the world was not sufficient. The victory that is now America's is America's only because she applied her science as an organized and efficient nation. With even greater emphasis can it be said of the trade war that is to follow the late military war that victory will be America's only in so far as we, her citizens, apply our science as an efficient organization, not as a heterogeneous mass of competing individuals. We have already made tremendous strides toward efficiency in insisting that a man purchase and use as little as he possibly can, not all that his credit will allow, and in the placing of curbs on the operations of the profiteer, the pooling of interests and the elimination of competition (which is the root and branch of inefficiency). These gains, which the President speaks of as "the by-products of war," must be retained and tremendously enlarged if we are to emerge from the second war with victory.

This efficiency, which will involve organization, coordination, co-operation, will consider waste on the one hand, both of labor and materials, and unused resources on the other. This will involve American potash in two ways. First, potash as a by-product (or with the aid of by-products) will become a permanent reality. Second, more conservativeness will be exercised in its use. We have been watching with interest the results on American agriculture of a great curtailment in the use of potash fertilizers. We have been asking ourselves how much the former wide and indiscriminate use of potash is based on actual scientific experimentation on American soils and how much on German propaganda.

American agriculture, formerly educated through German propaganda to the use of muriate and sulphate, with very little experimentation to determine the facts for itself, now finds itself applying to agricultural use a great variety of potash salts from a great variety of sources. There is a carbonate and sulphate from the alkali lakes of Nebraska, muriate from Searles Lake and kelp, carbonate from wood ashes and tobacco stems. and sulphate from alunite, cement mills, beet sugar residue and molasses. These are mixed in varying proportions with lots of other things present as impurities, and of questionable, if any, value as fertilizer. It has been a matter of ignoring ancient projudices in many cases or of doing without potash.

For example, muriate has been regarded as impossible for tobacco, and there potash has been regarded as a necessity. Are the tobacco growers using muriate, or are they doing without potash altogether where sulphate is not available? Does the presence of the small amount of borax found in muriate from certain sources act as a soil disinfectant and kill the soil bacteria essential to plant growth, or does it act as a stimulant, as poisons in small quantities so frequently do, and stimulate the growth of soil bacteria and thereby plant growth? Has the prejudice against muriate in California foundation in fact, or is it advice tendered by the German Kali Syndicate to the American farmers because sulphate formerly was produced only in Germany, and its use in our soils insured the use of German potash in place of local potash? It is unmistakable that there is a prejudice in California, for instance, against the use of muriate, the idea having been conveyed that

muriate contributed to the formation of alkali. It has not been possible to trace this idea to any experimentation actually performed by Californian experimentalists on Californian soils. It *has* been possible, however, to trace it to German propaganda. Knowing what we do about the nature of alkali in the soil and German propaganda, the question must be answered: Is not the Californian agriculturist making a mistake when he imports potash from Germany while ignoring the immense sources of potash at his own door?

Too much that is fundamental is involved in German science for us to question it without other reason than our late fear and hate of German world ambitions; but this we can surely say, that German propaganda has been written from the point of view of German profit. J. W. TURRENTINE.

Summerland, Calif.

Application of Nitro-Aromatic Compounds in Explosives Industry

To the Editor of Chemical & Metallurgical Engineering

SIR:—Two years ago I pointed out in your columns, March 15, 1917 ("The Application of Nitro-Aromatic Compounds in Explosives Industry"), that when the price of raw materials used in military explosives such as toluol and carbolic acid would drop from the abnormal prices of war to pre-war prices, it would be a good chance to convert TNT and picric acid into commercial blasting explosives. At the present time toluol and carbolic acid may be obtained at 18c. per gal. and 6c. per lb. respectively, and converted into TNT and picric acid at a respective cost of 10 to 12c. per lb. These purely military explosives cannot be used directly in commercial work, so it may be necessary to dilute and bring them to the grade of other standard blasting powders, like 40 per cent and 60 per cent standard dynamites, and at the same time eliminate the objectionable gases by mixing with oxidizing materials.

Thus there is a good opportunity for the picric acid and TNT manufacturers to continue making these nitro-aromatic compounds, by trying with a mixing outfit to convert these into commercial blasting explosives. The chance of success in explosive lines is much brighter than in the dyestuff business, which is almost overdone at the present time and does not present as big a future, commercially speaking.

During this period of waiting and readjustment it will be a good move on the part of TNT and picric acid manufacturers to investigate the possibilities of this proposition and to start preliminary tests and investigations on the properties and the powers of these new explosives. I have no doubt that they will find explosive engineers of tried experience and knowledge who will gladly co-operate with them in the application of TNT and picric acid to the explosive industry.

New York, N. Y. J. R. MARDICK.

High Stacks for Smoke Dissipation

To the Editor of Chemical & Metallurgical Engineering

SIR:—I notice in your editorial on "The Metallurgy of Copper in 1918" (Jan. 1, 1919) that you speak of high stacks and the resultant smoke dissipation as a recent development of Mr. O'Gara. The old 300-ft. stack on top of the hill at Anaconda, which carried the smoke 1000 ft. above the valley and 500 ft. higher than the tops of the original stacks, was built for this very purpose, as the reports made at that time will show. This stack and the long connecting flue were built on my recommendation and as a result of my investigations made for the Anaconda company in 1903. It was soon followed by the construction of the 500-ft. stack at Great Falls for the same purpose of smoke dissipation. It is needless to mention that the new stack recently completed by the Anaconda company, and much larger and higher than the old one, has been built on top the hill alongside the old one.

In passing I might say that the tremendous development of the reverberatory furnace to almost its present size and efficiency immediately followed the completion of the Anaconda stack and can be traced directly to its operation.

I do not wish to detract in the least from Mr. O'Gara's work, but it is only fair that credit be given to the pioneer work in this direction, which was done some time before the Cottrell process was invented.

Denver, Colo. STUART CROASDALE.

A Great Opportunity for Intelligent Location of Industries

To the Editor of Chemical & Metallurgical Engineering

SIR:—With the sudden emergence of the United States from a secondary political position to that of a world power, we have had thrust upon us one of the greatest opportunities for internal development ever placed before our people. The natural resources of our country are the envy of the world. Agriculture, mining, manufacturing and transportation flourish side by side and ever on an increasing scale. Abroad, however, we are known as producers of raw materials, principal among which are cotton, wheat, steel, meat and petroleum. Our manufactured products go largely to a home market—not more than 8 per cent of those produced in 1915 were exported.

It has been a creditable performance to export a large tonnage of raw materials to the artisans of Europe. Their distribution through the markets of the world as finished products by laborers of other countries is to our national discredit. It was very natural that masters of ships subsidized by their home Governments should carry the manufactured articles made by their own people and that export trade in articles manufactured in the United States should languish. But we are promised better treatment!

American shipping calling at the principal ports of the West Indies, of Mexico, South Africa, South America and the Orient is ready to carry our commodities to all of the great markets of the world. Our broadened national policy is particularly interesting to the manufacturer. Raw materials may be worked into their ultimate products at home, giving employment to many people and adding greatly to our national wealth and influence. To meet the situation we need to enlarge our existing plants and to add scores of new industries wherever conditions are favorable for their maintenance.

The modern American city is the nucleus of successful manufacturing and the phenomenal growth of 90 per cent of the towns of the United States is due to a recognition of this fact. There are about 175 cities in the United States each with a population of more than 25,000. Every one of these towns is a good location

for *one* or *more* industries and the *best* economic *location for at least one*. This may be due to the presence of an important raw material, a remarkable climatic condition or an unusual market. The iron ore industry of Duluth is an example of the first; the growth of the moving picture business at Los Angeles is an example of the second; and the Alaskan trade controlled by Seattle illustrates the third.

No other branch of industry can excel manufacturing from a labor standpoint. Employment is usually constant throughout the year. Both male and female help is utilized and under our present financial system, payment is prompt, with a fair wage. Capitalists and bankers are eager to lend financial support to a legitimate manufacturing business, and expect a good return upon the investment, if it is well managed. Examples of remarkable dividend paying enterprises are the well established cotton mills of New England, the steel plants of Pittsburgh or the various plants of the General Electric Co. The average annual sales of a stable manufacturing business are usually about equal to the capital stock invested and the net income in many instances averages 20 to 25 per cent.

The accumulation of sufficient wealth conservatively invested to insure leisure tempts thousands of men to move into small cities, where they live useless and comfortable lives. If such men dictate the policy of a town it is placed on the traveling man's map as "dead." There are hundreds of such places pretty well distributed throughout our national territory. In the country roundabout, the wealth that the Creator placed in the ground remains unsought for, the land is aimlessly tilled, and the fruit rots on the trees.

We have just emerged from national scarcity of many things, and the lesson should awaken every live man of influence to a sense of responsibility and to line up the raw materials and the men and women of his locality to produce useful manufactured commodities for the people of the world. One good industry employing a thousand people will transform a self-sufficient "retired business men's" town into a thriving village or city. One live man can make this change, with proper backing from the controlling financial forces.

Until very recently bankers have preferred to handle real estate and mortgages than to lend to manufacturers. In many instances, foreclosures on mill property have been the direct result of a short-sighted system of discrimination against even the best commercial paper. A bank is a public institution, one of the purposes of which is service to the community. If manufacturing has not been popular among the business men of a town it is the duty of the local banks to employ technical assistance, and determine what can be made and sold to advantage in that locality. With proper financial support a plant may be erected and a business started.

While the banker has been conservative in industrial matters, our business men of many cities have combined forces and have, through their commercial associations, attracted industries that have enriched the life and business of the town in every way.

We foresee an intensive study undertaken by every municipality to determine what can best be manufactured in that place. We remember Schenectady as a sleepy cobblestone-paved town of 12,000 people. The presence of an industry of national scope and interests has made a modern city of nearly 100,000; 25,000 of these are men and women who earn good wages with one concern.

If a town has grown through the manufacture of a raw material the supply of which will soon be exhausted, the public spirited citizens of the place should attempt to find a substitute before the actual death of the business. The sawing or handling of lumber is an example. Many prosperous mining towns of the West are depopulated when paying ore ceases to be found.

Among the fundamental elements of a location to be studied are the following:

Raw Materials	Climate
Market	Hygienic Conditions
Transportation	Public Utilities
Labor	Housing
Water Supply	Banking Facilities
Power Cost	Taxes and Insurance
Education and Public Spirit	

For some reason not at first evident the greater portion of the manufacturing of the United States is carried on within an area bounded by lines connecting Portsmouth, N. H., Milwaukee, Wis., St. Louis, Mo., and Baltimore, Md. Since 1850 manufacturing investments in this territory have increased from a few hundred millions to more than twenty-five billions. The general reason for the growth in this limited area is the adaptability of the people to the climate and topography, with ample fuel and raw material supply. Intelligent white labor lives and thrives in a belt about two hundred miles north and south of the fiftieth isothermal degree from the Atlantic to the Mississippi River. Colored labor, Mexicans and the Japanese are available in the warmer sections of the country, so that it is possible to operate a plant irrespective of the latitude. Any town in the United States located on a railroad may have some natural product that can be manufactured into a useful material for home market or export.

Our climate varies from semi-tropical to cool-temperate. A business that requires much sunshine may be located in New Mexico, Arizona or California. For cotton manufacture, a high relative humidity is found along the Atlantic and Gulf coasts; if high altitude is essential this may be found in Salt Lake City, Denver and Cheyenne.

But natural elements are not all. The temper of a city is told by the spirit of its people. No prospective manufacturer wants to try to do business in a town which is itself antagonistic or indifferent. The founders of what has become a manufacturing business of national scope asked the leading men of a conservative Eastern city if they might locate a plant in that place. A negative answer was given, with the comment that "their town did not want the noise and smoke incident to the enterprise." It often occurs that the lives, happiness and well being of 10,000 people depend upon the main industry of the place.

A careful location study includes the foregoing and much more. Given the selection of a manufacturing site for a large industry, all good location areas should be investigated, and that one selected which seems to embody the greatest number of favorable factors.

WILLIAM MILLER BOOTH.

Syracuse, N. Y.

Report of Alien Property Custodian on the Metal Industry

CHAPTER III of the report recently made by the alien property custodian to the President contains a great many interesting revelations regarding the German domination of the metal markets of Europe, particularly those of zinc and lead. The intricate relationships existing between the numerous German-owned or controlled companies are shown graphically in the accompanying drawings.

While Germany has never been a great producer of metals, yielding only 3 per cent of the world's copper, 28 per cent of the refined zinc and 16 per cent of the lead, yet she has exercised almost complete control of the zinc and lead markets of the world outside the United States. The alien property custodian finds the secret of this power in the fact that the great German metal houses have acted in concert in the purchase of zinc and lead ores, control of smelters and refineries, and have been favored by unlimited credit from German banks.

The German metal triumvirate are the Metallgesellschaft of Frankfurt, Aron Hirsch & Sohn of Halberstadt, and Beer, Sondheimer & Co., of Frankfurt. These vast concerns developed out of very small ventures.

(1) *The Metallgesellschaft* is the largest of these concerns and is by far the most powerful metal concern in the world. It is a stock corporation with a capital of 18,000,000 marks. It is the outgrowth of the metal business founded by Philip Abram Cohn early in the nineteenth or late in the eighteenth century. In the early '60s of the last century, Henry Merton, whose real name was Moses and who was related to Philip Abram Cohn, founded a metal firm in London which later became the powerful house of Henry R. Merton & Co., Ltd. The Metallgesellschaft and the Merton firm worked hand in hand for the advancement of German domination of the metal markets of the world.

(2) *Aron Hirsch & Sohn*, a copartnership, is the business founded by Aron Hirsch and it has always been kept in the Hirsch family. This house has not confined itself strictly to metal trading but has also engaged in metal manufacturing. It has interests all over the world.

(3) *Beer, Sondheimer & Co.*, a copartnership, was founded in the latter part of the '70s by Messrs. Beer and Sondheimer, two salesmen of Metallgesellschaft, who broke away from the Metallgesellschaft and with the assistance of the Mitteldeutsche Credit Bank started in business for themselves under the name of Beer, Sondheimer & Co. This firm has confined its activities principally to the zinc smelting business.

THE ZINC SYNDICATES

At the outbreak of the European war these three concerns controlled the zinc industry of the world with the exception of the United States. The control of the purchase of Australian ores was exercised by means of joint accounts resulting in the elimination of nearly all competition both in the purchase of ore and its allotment to European smelters.

This Australian zinc-ore purchase combine was followed by the formation of the German Zinc Syndicate, comprising all the large zinc concerns of Germany for the purpose of fixing prices in Germany. The formation of this syndicate was met by the formation of an English syndicate and a Belgian-French syndicate. The most important Belgian concern, however, the Société Vielle Montagne, which had extensive works throughout the world, was in a working agreement with the German Zinc Syndicate, so that the latter's preponderance over all the others was so great that they were forced to join the Germans in the formation of the International Zinc Syndicate in 1911. The purpose of the syndicate is stated as follows:

> A curtailment of production is to be effected whenever the stocks held by the various zinc smelters at the end of a quarter exceeds 50,000 tons; provided, however, that if the price of spelter in London should be £23 or more no curtailment of production is to take place.

Production and price were regulated and agreed upon from time to time according to the necessities of the market. The sale of the metal was placed in the hands of three principal German concerns which the alien property custodian designs as the triumvirate.

THE LEAD SYNDICATE

At the outbreak of the European war the lead output of the world was likewise centered in the hands of the Germans. The Metallgesellschaft had the exclusive sales agency of what was known as the international lead convention, which was formed in 1909 and continued thereafter for a number of years. It embraced the principal Australian lead producers, as well as most of the German, and most of the Spanish and Belgian lead mines. At least two American firms, to wit, the American Smelting & Refining Co. and American Metal Co., as far as their production of lead from ores imported in bond is concerned, and some of the Mexican mines, were likewise members of the syndicate which regulated output and fixed prices.

COPPER

The situation in copper, however, was quite different, and the Germans were never able to get control of production. This was due largely to the fact that the United States output, which is more than 60 per cent of the world's total, could not be brought under German domination. Outside the United States, however, the Germans largely controlled the copper output. Germany also exercised a powerful influence over the price of the metal through the activities of the metal triumvirate, as well as because she was a large consumer.

The power which these concerns exercised in the market is believed to lie in the unlimited credit at their command for financing large purchases of copper for long periods of time, including periods of depression.

THE GERMAN METAL TRIUMVIRATE IN THE UNITED STATES

At the outbreak of the European war each member of this triumvirate had a branch of its business in the United States. The Metallgesellschaft had the American Metal Co., Aron Hirsch & Sohn had L. Vogelstein & Co., and Beer, Sondheimer & Co. had a branch under its own name. All these branches were located in New York City, and all developed vast and extensive interests in the United States, Mexico, and South America, including the control of mines, smelters, and refineries.

(*a*) *American Metal Co., Ltd.*—In or about the year 1887 Metallgesellschaft sent to the United States two of its representatives, to wit, Jacob Langeloth and Berthold Hochschild, to establish a branch of the Metallgesellschaft's business. At that time the present banking firm of Ladenburg, Thalmann & Co. were doing a metal business and had connections with the Metallgesellschaft. An arrangement was made resulting in the organization of a corporation called the American Metal Co., Ltd., under the laws of the State of New York, with a capital of $200,000, divided into 2,000 shares, to which corporation Ladenburg, Thalmann & Co. turned over their metal department. The stock of the corporation was issued as follows:

	Shares
Metallgesellschaft	600
Henry R. Merton & Co.	595
Ladenburg, Thalmann & Co.	710

The balance of the stock was allotted to various officers. It will be noted that from the very organization

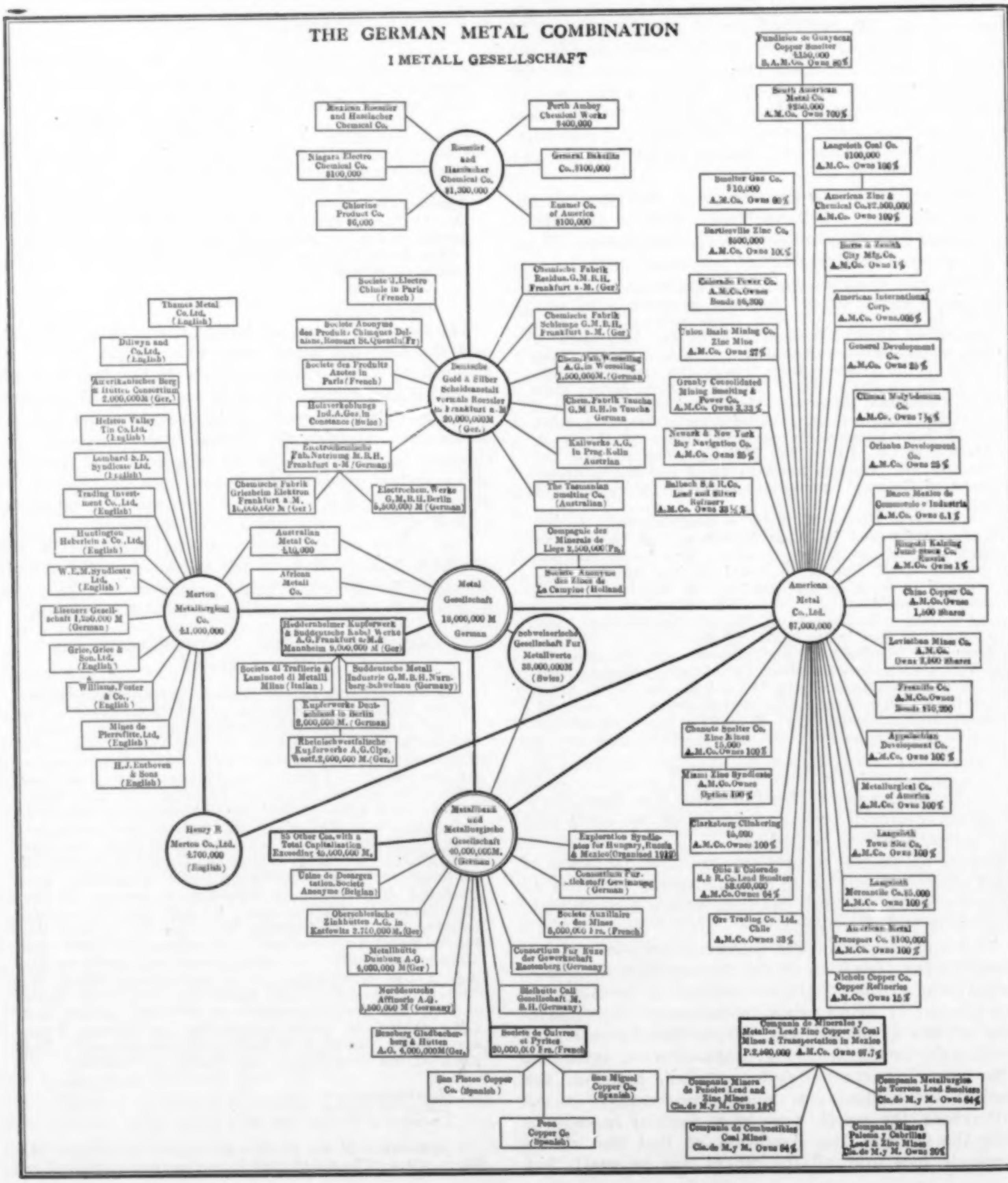
of the American Metal Co. the stock control thereof was in the hands of Henry R. Merton & Co. and the Metallgesellschaft. These German interests continued to retain that control through all the years of the development of the American Metal Co., and had the control at the outbreak of the European war. The capital stock of the American Metal Co. was increased from time to time until in 1917 it was $7,000,000.

The entire turnover of the company in copper is about 250,000,000 lb. per annum, which is about 15 per cent of the country's total production of copper.

The report of the alien property custodian gives the following statements of average annual quantities of products of the American Metal Co.

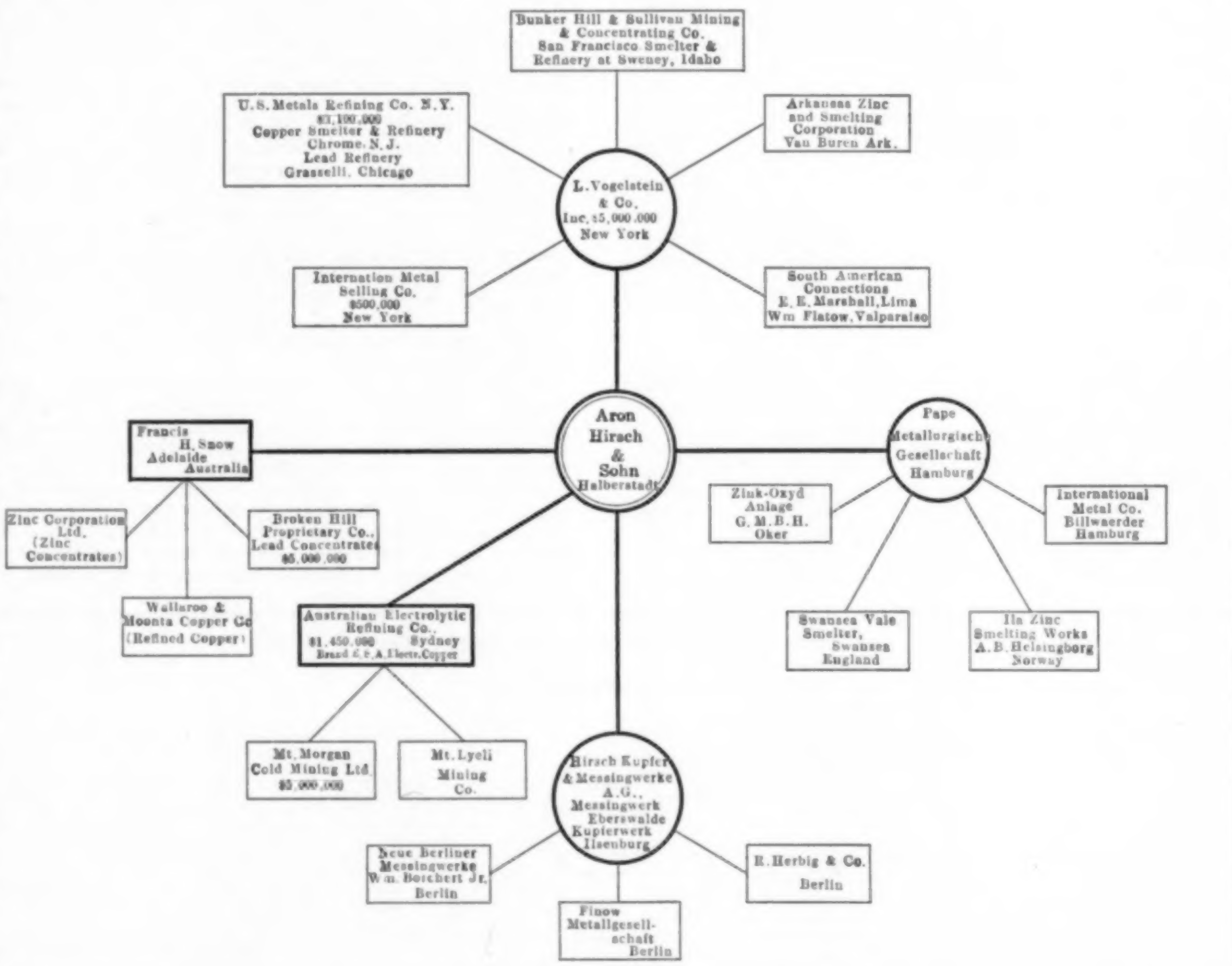
Electrolytic copper	100/125,000,000 pounds
Zinc (spelter) all grades	75/100,000 tons
Bonded (Mexican) lead	60/75,000 "
Domestic lead	12/15,000 "
Sulphuric acid	80/100,000 "
White arsenic	4/6,000 "
Coal in Pennsylvania	350/400,000 "
Coal in Mexico	500/600,000 tons
Silver	12/15,000,000 ounces
Zinc oxide (Polar and Arctic brands)	7/10,000 tons
Zinc dust (American Extra Pure and Zenith brands)	3/4,000 "
Antimonial lead	1,000/1,500 "
Molybdenum concentrates	500/1,000 "

The zinc ores purchased by the American Metal Co. and treated by the smelters of its domestic subsidiaries for the two years ended June 30, 1917, amounted to approximately 1,700,000,000 lb. In addition to that



THE GERMAN METAL COMBINATION

II ARON HIRSCH UND SOHN



the company purchased spelter during those 2 years in the open market amounting approximately to 585,000,000 lb. The production of lead for 1917 was 168,000,000 pounds.

(*b*) *L. Vogelstein & Co., Inc.*—Aron Hirsch & Sohn was 10 years behind the Metallgesellschaft in establishing a branch in the United States. In 1897, Ludwig Vogelstein started an agency for Aron Hirsch & Sohn in New York. Soon thereafter Vogelstein formed the firm of L. Vogelstein & Co. and associated with himself one Ernest G. Hothorn. In the firm Aron Hirsch & Sohn had a direct interest. The business was conducted as a copartnership until the end of 1916, when the present corporation, L. Vogelstein & Co., Inc., was formed. During these 19 years the Vogelstein business was conducted purely as an agency of Aron Hirsch & Sohn. There were agreements between Vogelstein and the Hirsch concern for the division of profits upon the American business and upon some of the European business.

The more important activities of the Vogelstein concern comprised the erection of a copper refinery at Chrome, N. J., in co-operation with Capt. J. R. DeLamar; the organization of the International Metals Selling Co. to facilitate the sale of the refinery's product; and arrangement with the American Zinc, Lead & Smelting Co. for the sole sale agency of that concern; the organization of the Arkansas Zinc & Smelting Corp. and the erection of a zinc smelting plant; and contracts with other smelters and refineries for exclusive selling agencies.

The total annual turnover during the last five years was as follows:

Copper (870,931,737 lb.)	$207,196,741.36
Gold (578,138,191 oz.)	11,870,104.67
Silver (25,120,134.16 oz.)	17,166,113.45
Lead (323,099,014 lb.)	18,320,735.68
Spelter (397,740,356 lb.)	47,814,011.40
Tin (91,128,623 lb.)	37,035,647.83
Miscellaneous	3,134,834.31
	$342,538,188.70

(*c*) *Beer, Sondheimer & Co., Inc.*—Beer, Sondheimer & Co. of Frankfurt established a New York branch in 1906. Like the Metallgesellschaft, it sent over two young men, Benno Elkan and Otto Frohnknecht, who established the business here under the name of Beer, Sondheimer & Co., American Agency. The name was subsequently changed to Beer, Sondheimer & Co., American Branch, and the business was conducted under that name until August, 1915, when it was incorporated, under circumstances which will be hereinafter discussed. The New York business was owned at all times by the Frankfurt house, Elkan and Frohnknecht being only agents upon a salary and a profit-sharing basis. The ramifications of the company in the metal business are shown in the chart.

The following table shows copper, spelter and lead turnover of Beer, Sondheimer & Co. for several years:

TOTAL TURNOVER

	Lb.	Value
Spelter dealt in:		
1915	73,143,943	$8,118,004
1916	75,563,802	10,342,882
1917	57,459,556	5,330,090
1918	49,814,465	4,131,826
Total	255,981,766	$27,922,802
Lead dealt in:		
1915	6,210,758	278,716
1916	5,754,419	378,096
1917	6,230,411	527,232
1918	673,727	70,539
Total	18,869,315	$1,254,583
Copper dealt in:		
1915	17,071,632	2,559,490
1916	24,295,095	5,530,191
1917	27,056,933	7,326,273
1918	10,450,315	2,627,004
Total	78,873,975	$18,052,958

MINERALS-SEPARATION AGENCY

The history of Beer, Sondheimer & Co.'s activities in the United States would not be complete without mentioning its connection with the various minerals-separation companies.

In 1906, Henry Livingstone Sulman, Hugh Fitzalis, Kirkpatrick Picard, and John Ballot, all of London, England, claiming to be the inventors of the new process, obtained a patent thereon in the United States. In 1910, Sulman and Henry Howard Greenway and Arthur Howard Higgins, all of London, obtained another patent in the United States, and in 1914, Greenway, then of Melbourne, Australia, obtained a third patent in the United States, the latter two patents involving the same process as the first one, but including improvements thereon. These patents run for a period of 17 years from their respective dates.

In 1905, and before the first United States patent was obtained, the patentees obtained a patent in England exactly similar to the first United States patent. The validity of the English patent was attacked in the English courts, but was sustained by the House of Lords. (Minerals Separation, Ltd. vs. British Ore Concentration Syndicate Ltd., 27 R. P. C., 33.)

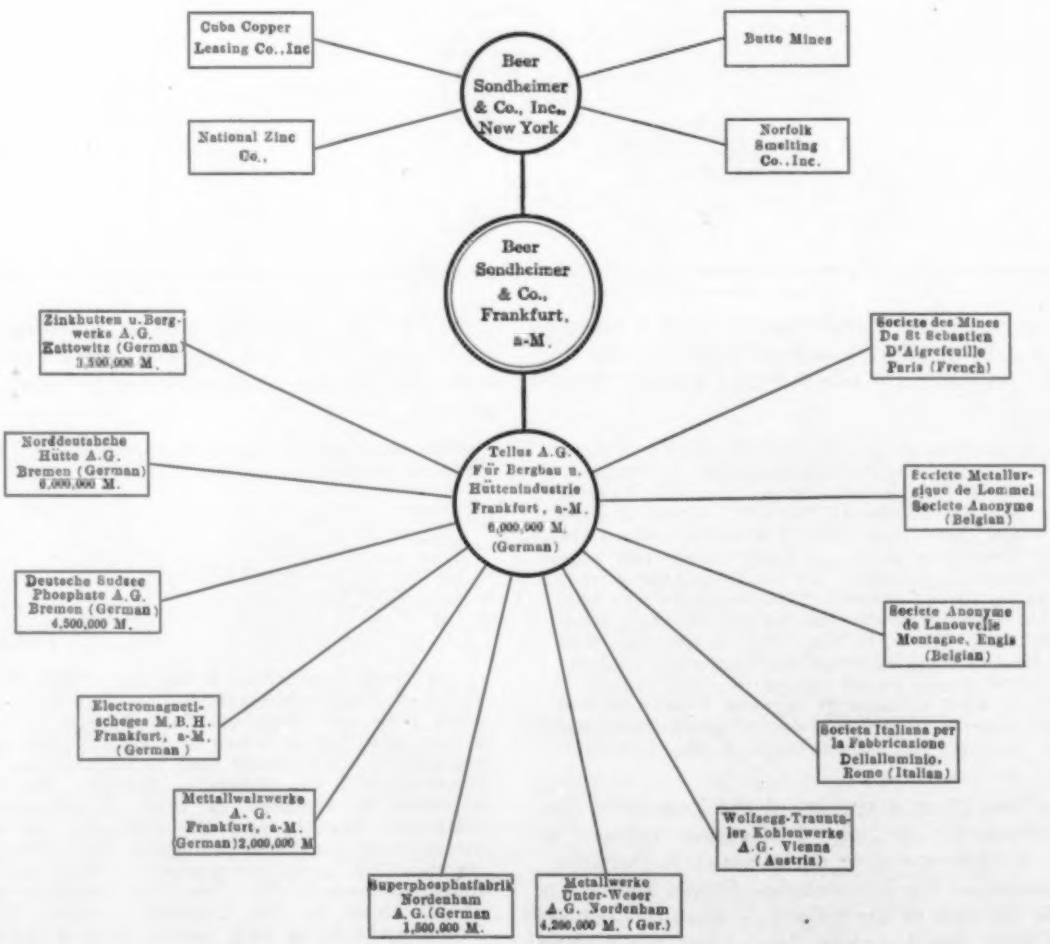
In 1903, Minerals Separation, Ltd., which will be hereafter designated as the parent company, was formed under the English law. The three United States patents were assigned to this company.

In 1910, the parent company having acquired the United States patents, and similar patents obtained in Canada and Mexico, conveyed these patents to a corporation called Minerals Separation American Syndicate, Ltd., for the purpose of enabling the American syndicate to exploit these patents in America. This, too, was an English corporation.

In 1911 the American syndicate made a contract with Beer, Sondheimer & Co., whereby it gave to that firm the exclusive agency to represent the syndicate in America. For reasons which are unimportant to the present inquiry, this first American syndicate was soon dissolved and a new syndicate was formed, called Minerals Separation American Syndicate, 1913, Ltd. This, too, was a British company. The 1913 syndicate renewed the agency agreement of Beer, Sondheimer & Co., and appointed that firm sole agents to conduct all

THE GERMAN METAL COMBINATION

III BEER SONDHEIMER & CO.



of the syndicate's commercial affairs in the United States, Canada and Mexico, the agency to continue for a minimum period of 10 years with a provision for renewal for the rest of the life of the patents. Beer, Sondheimer & Co. were to receive a commission of 10 per cent of all gross royalties received for the use of the patents and 10 per cent on all profit-sharing business (the syndicate intending not only to give licenses, but also to buy up and treat ores), and also a percentage as a commission of the sale of products so treated by the syndicate.

When the agency agreement was made Beer, Sondheimer & Co. had an American branch of its business in New York City, which was in charge of Benno Elkan and Otto Frohnknecht, and was being conducted under the name of Beer, Sondheimer & Co., American Branch. The parties entered into the performance of the agreement, and inasmuch as most if not all of the business was done in the United States the agent's end of the business was conducted by the American branch of Beer, Sondheimer & Co.

In addition to having the exclusive agency, Beer, Sondheimer & Co. were also stockholders of the 1913 syndicate, owning 32,615 shares of said stock. In 1916 the property of the 1913 syndicate was conveyed to an American corporation called Minerals Separation North American Corporation, and each stockholder became entitled to two shares of the American corporation's stock for each share of the 1913 syndicate stock.

The importance of the control by this German-owned branch of Beer, Sondheimer & Co. of the minerals-separation process, and the power to grant or withhold from the United States metal-industry licenses to use the flotation process, can hardly be overestimated. The custodian, as will be pointed out later, has taken over all of the minerals-separation stock held by Beer, Sondheimer & Co., and the latter's control of the minerals-separation process in the United States has broken.

Disclosures by Investigations Conducted by Alien Property Custodian

After the passage of the trading with the enemy act in October, 1917, and the subsequent appointment of the alien property custodian, he caused investigations to be made of the American Metal Co., Vogelstein & Co., and Beer, Sondheimer & Co., as a result of which he took over the entire business of Vogelstein & Co. and of Beer, Sondheimer & Co. and 49 per cent of the stock of the American Metal Co. The investigations disclosed the following state of facts:

As to Beer, Sondheimer & Co. it was shown that legal subterfuges were adopted for the express purpose of making it impossible for the United States Government in case of war between the United States and Germany to exercise its belligerent rights and take control of enemy property in the United States. It was further disclosed that Messrs. Elkan and Frohnknecht were citizens of the United States; they did not become such until 1917. One of them became a citizen after Von Bernstoff got his passports and the other after we were at war with Germany. "There is evidence to indicate that their sudden desire to embrace our citizenship was only a 'war measure' after all and that they asked for and obtained the approval of the Frankfurt firm to their action."

As a result of his investigations the alien property custodian demanded and took over the entire business assets of Beer, Sondheimer and Co. as German property.

As to L. Vogelstein & Co., the alien property custodian has taken control of the business and is in possession of the entire capital stock, including the interest of Aron Hirsch & Sohn.

As to the American Metal Co., the alien property custodian demanded and received all of the 34,644 shares of stock owned by the Germans and appointed 5 out of the 15 directors of the company to represent him in the conduct of the affairs of the corporation.

As to Beer, Sondheimer & Co.—The business of Beer, Sondheimer & Co. is in process of liquidation. This includes not only the corporation Beer, Sondheimer & Co., Inc., but also its subsidiaries, the National Zinc Co., the Norfolk Smelting Co., and the Cuba Copper Leasing Co. It includes also the 100,000 shares of the stock of Minerals Separation North American Corporation out of a total issue of 500,000 shares. This stock will be disposed of by the custodian and will go into American hands.

As to Vogelstein & Co.—As in the case of Beer, Sondheimer & Co., when the custodian took over the business of L. Vogelstein & Co., Inc., he placed in control thereof a board of directors designated by him. Subsequent investigation by the custodian disclosed that Vogelstein, who was a naturalized American citizen, had a preponderating interest in the assets of the corporation, and inasmuch as it has as yet been impossible to obtain from Aron Hirsch & Sohn an accounting so as to determine that concern's exact interest in the assets of L. Vogelstein & Co., Inc., an arrangement has been perfected between the custodian and Vogelstein whereby all of the stock of the corporation has been put into a voting trust for a period of five years, the custodian naming two of the three voting trustees. Thus the control of the corporation for the next five years will be in the hands of trustees appointed by the alien property custodian. Vogelstein has agreed not to resume his relations with the Germans during this period of five years and to conduct the business of the corporation as a purely American concern. Vogelstein has agreed to pay to the custodian $1,668,671.49, being the amount of the apparent indebtedness from him to the Hirsches as of April 30, 1916, and has agreed to pay to the custodian all additional moneys that may be found to be due to the Hirsches upon a final accounting which is to be had within six months after the declaration of peace. Thus circumscribed and guarded, the control of the business has been turned back to Vogelstein, the custodian retaining two out of the five places on the board of directors as long as the custodian may have any interest in the business.

Stock Put in a Voting Trust

As to American Metal Co.—Soon after the trading-with-the-enemy act became a law, the Americans in control of the American Metal Co. not only promptly filed the report required by the act and disclosed therein the German ownership of about 49 per cent of the stock of the company, but offered to co-operate with the custodian in any direction looking to the elimination of the German interests. An investigation of the affairs of the company was courted and at the instance of the War Trade Board such an investigation was made and subsequently the alien property custodian likewise made an investigation of his own. The officers of the company heartily co-operated with the alien property custodian, which resulted in the first instance in the transfer to the custodian of the stock belonging to the Germans. The custodian was satisfied with the good faith of the management of the corporation and therefore designated but five out of the 15 directors of the company.

By agreement between the alien property custodian and the American stockholders, together controlling 53,264 shares (out of 70,000 shares outstanding) all of said stock has been placed in a voting trust for a period of five years. The alien property custodian is entitled to receive voting trust certificates representing the 34,644 shares of stock formerly held by enemy aliens. It is his purpose to offer these certificates for sale to the American public at public auction.

The policy of the alien property custodian to sell only to Americans will be strictly adhered to in this instance, and none of the voting trust certificates will be permitted to go into any but American ownership. The immediate result is that 76 per cent of the stock of the company will be owned by American citizens. The alien property custodian is in correspondence with the British authorities with a view to the deposit under the voting-trust agreement of the 16,736 shares held by Henry R. Merton & Co. and its allied interests. It is hoped that such action will be taken in the near future. When this has been done, the alien property custodian believes that all German ownership and influence will be effectually eliminated from the company.

Supreme Court Hears Minerals Separation vs. Butte & Superior

THE argument before the U. S. Supreme Court in the Minerals Separation vs. Butte & Superior infringement suit was heard on Wednesday, March 19. No extension of time was requested, as in the Hyde case, and there were no experimental demonstrations, as in that case. The plaintiff, Minerals Separation, divided its time into an opening and a closing, half an hour each; defendant, Butte & Superior, having the intervening hour.

In opening, counsel for Minerals Separation explained to the court that in the Hyde case the question before the Supreme Court had been as to the validity of the patent (835,120), the acts of infringement in that case having been clear. In the instant case, however, the Supreme Court having established the validity of the patent, the question before the court is as to the infringing nature of the defendant, who, previous to the Supreme Court decision, had been using about two-tenths of 1 per cent of pine oil, alone, as the flotation agent, but who immediately upon the Supreme Court's finding in favor of the validity of the patent, had, while continuing the use of the pine oil, to very little more than two-tenths previously used, added thereto eight-tenths of 1 per cent of petroleum oils, which the District Court, after a lengthy hearing, had found to be utterly useless as a frothing agent, and as the defendant had admitted was a wasteful use of oil.

Several of the Justices questioned counsel as to the limiting amount of the process, recalling to mind the colloquy which had taken place in the Hyde case, which colloquy was so prominently set forth in the opinion of the Court of Appeals in the present case. Counsel claimed that in that case counsel for plaintiff had been speaking of the use of oleic acid upon Broken Hill ore, and that the patent explained that for different ores and different oils, different proportions were required, and that the proper proportions in each case could only be ascertained by experiment. In argument, and in response to inquiry from the Justices, counsel for Minerals Separation insisted that these petroleum oils were absolutely useless as frothing agents and even actually harmful, so that the pine oil, which had previously done the work and was still doing the work, had to be slightly increased.

Counsel for the defendant, Butte & Superior, in opening stated that he came before the court with no intention whatever of questioning the court's decision in its sustaining the validity of this patent. He was anxious, he said, to assist the court in interpreting its decision, and with this end in view would recall the subject as it was presented to the court, going quite fully into the emphasis which had, in the Hyde case, been placed upon the "critical" proportions of oil, the minute, microscopic quantities, and showed that plaintiff's experts, as well as the patent itself, confined the process to these minute quantities; the plaintiff's own witnesses having testified that for all ores and all oils the world over, the proportions varied between 0.05 and 0.2 per cent. The colloquy of the Hyde case was also quite fully quoted.

The counsel for the defendant then took up the question as to the use of petroleum oil in flotation practice, showing the very general use of just such mixtures as defendant is now using, of mixtures of vegetable and mineral oils, and in the same relative proportions, by the licensees of Minerals Separation. He also quoted from the testimony of complainant's own witnesses as to the beneficial use of petroleum oils, and quoted the original English patent in which oleic acid and petrol are always specified together as absolutely equivalent. The first written report of the discovery also was quoted as showing the fact that petroleum oils were suitable oils.

The question as to the delay in filing a proper disclaimer of the three "small quantity" of oil claims was then taken up by counsel for defendant, who claimed that the disclaimer as filed was in fact no disclaimer whatever, but actually broadened the three claims in question by a tricky use of the wording of the Supreme Court decision in the Hyde case, in which the Supreme Court said: "The patent must be confined to the results obtained by the use of oil within the proportions often described as in the testimony and in the claims of the patent as 'critical proportions.'"

In the disclaimer they so repeated the words, "results obtained," as to make the disclaimer read that these claims are limited to a process in which the "results obtained are the results obtained by the use of" the critical proportions of oil. From this counsel argued that according to the statutes covering the question of disclaimer, the plaintiff, having up to this time in fact made no disclaimer, has no right to maintain a suit upon this patent.

In closing argument, counsel for plaintiff urged strongly the position that the use of petroleum in such manner did not conform to the prior art, as prior art was classified by the Supreme Court decision in the Hyde case. Oils, it was argued, have other necessary qualities than the "preferential affinity" referred to, as for example in Cuttermole process the additional property of forming granules. In this case the frothing quality was lacking for defendant's ore, citing an experiment before the District Court and claiming that defendant had never in its practice used petroleum oil alone. The gist of the Minerals Separation argument was that, when an oil will not effectuate, the process of the patent in suit, it is not an oil of the process. That appears to be that for one ore petroleum may be an oil of the process, while for another ore it may not be an oil of the process.

As to the disclaimer, the counsel for the plaintiff said that the "small quantity" claims 9, 10 and 11 were of a group different from all the other claims of the patent in that they were not limited, as the other claims of the patent, to a process which is obtained as the result of a froth formed by oil-coated mineral matters.

Arguments upon both sides were very able, and while one may question the advisability of attempting, in so limited a time, to cover so wide a subject as this case presents, it is perfectly clear that it was not possible even to touch upon many of its important features. The Justices were most attentive, showing an unusually keen interest from the very first word to the end of the arguments.

Civil Service Examinations

The United States Civil Service Commission announces open competitive examinations for junior metallurgist and junior mining engineer, for men only, April 15, 1919. Entrance salary, $1200 to $1500 a year. There are vacancies at Seattle, Wash., and Pittsburgh, Pa.

New General Import License

The necessity of obtaining individual licenses for the importation of unrestricted commodities from the United Kingdom, France, Italy or Belgium, or any of their possessions, may be avoided by using the general import license PBF 34, issued by the War Trade Board on March 6.

The following restricted commodities are expresslyexcluded from the terms of this license: Pig tin, tin ore, tin concentrates, all metal alloys containing more than 20 per cent tin, spiegeleisen, ferromanganese, emery, except that produced in Canada; salvarsan, neosalvarsan, arsephenamine, and all substitutes therefor and equivalents thereof; nitrate of soda, sugar.

Manganese and Chromium in California

Owing to the increased interest in manganese and chromium during the period of the war, all known deposits in California were visited and examined by members of the field staff of the State Mining Bureau. The results of these investigations are embodied in Bulletin No. 76, which may be obtained for 50c. postpaid, from the State Mining Bureau, Ferry Building, San Francisco.

As this is the only recent publication giving detailed data on the manganese and chromium resources of the entire State, it is still of value, in spite of the fact that the situation which led to the investigations no longer exists.

Waste Paper-Mill Bark as a Source of Tannin

The feasibility of using waste hemlock bark from paper-mill operations for tanning purposes has been further demonstrated in recent tests made by the Forest Products Laboratory. Results obtained first in an experimental way were so encouraging that the investigation was finally carried out on a semi-commercial scale in co-operation with a paper mill, a tannery and a manufacturer of drying equipment.

The conclusions reached are : (1) no great technical difficulties stand in the way of utilizing paper-mill bark for such purposes; (2) the product is satisfactory from the tanner's standpoint; (3) it can be prepared at a cost which will allow it to compete with leaf bark.

The use of paper-mill bark for tannin would mean a source of income for the paper mill from a material which is now of little or no value. In many cases it would also be the solution of a serious problem of stream pollution. The tanner would be assured of a constant supply of dried bark which would allow him to keep much less material in stock, to reduce his fire hazard and to wipe out the depreciation and interest charges which must be carried against a yard full of leaf bark. The lumberman would avoid increasing difficulties of obtaining satisfactory labor for bark peeling and would do away with the fire hazard and expense incidental to the peeling and seasoning operations, all of which combine to make the production of leaf bark an unsatisfactory business, even at the present market price.

It is believed, therefore, that utilization of waste paper-mill bark for tannin is a conservation measure which from every standpoint is worthy of being put into immediate practice.

Exhibit on Method of Classification of Personnel

Employers and others interested in personnel work will have an opportunity to examine the methods developed by the Committee on Classification of Personnel in the Army at an exhibit to be shown on the third floor of the Engineering Societies Building, 29 West 39th Street, New York City, April 1 to 12. The exhibit consists of a collection of wall charts, forms, photographs and models showing how the Army finds out what men can do best and how it uses that information; how soldiers are trade-tested, and how officers are rated and fitted into place; how the work is checked and supervised, and its results in the war. The collection is being shown under the auspices of the National Association of Corporation Schools and the United Engineering Society.

Opportunities for Disabled Men

The Federal Board for Vocational Education has suggested the positions of safety engineer and safety inspector as being suitable for men who have lost one eye or one arm but who still retain fair hearing and the use of both legs. Opportunities for work are numerous, as insurance companies, large industrial concerns, the Interstate Commerce Commission and various State and municipal departments offer good positions of this sort. The salary of the safety inspector will range from $1200 to $2000 a year and the course of training should be not less than three months, while those wishing to qualify as safety engineers, with a salary range from $1800 to $3000 per year, should continue their studies for at least six months.

Surplus Acid in the War Department

The Director of Sales, War Department, states that approximate quantities of surplus acid held by the Department on March 13 were as follows:

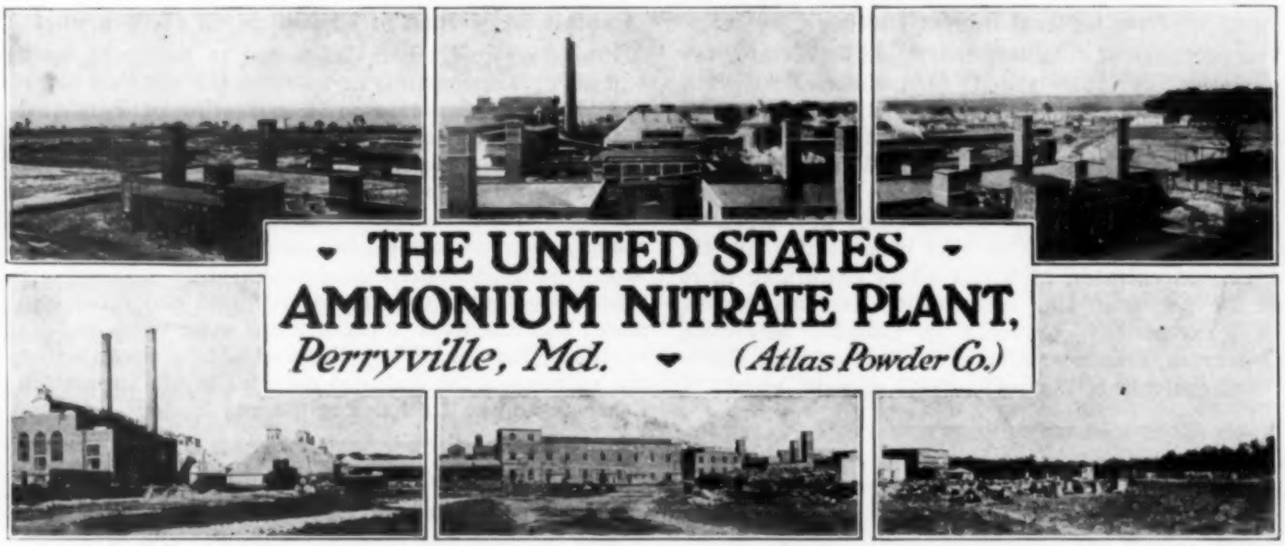
Sulphuric acid	4400 tons
Oleum	300 tons
Nitric acid	1000 tons
Mixed acid	2600 tons
Spent acid	700 tons

These quantities are very small compared with the total production and consumption of the country, nevertheless the Government will not dispose of it in such a way as to affect the market seriously.

Expansion of Japan's Trade During the War

A detailed trade study of Japan for the years 1913 to 1917 just issued by the United States Tariff Commission indicates striking changes in the commerce, industry and financial position of that country during the war period. Japan's total trade rose from $680,500,000 in 1913, to $1,319,000,000 in 1917, an increase of 94 per cent.

A special section of the report is devoted to the trade between Japan and the United States, from which it appears that at present the United States supplies a little over one-third of Japanese imports and takes nearly 30 per cent of Japan's exports. The sales to Japan consist mainly of ginned cotton, iron and steel, construction materials, machines and engines, and petroleum, while the purchases from Japan are made up principally of raw silk, silk tissues, tea, hemp and straw braids for making hats, champhor, beans and peas, porcelain, starch, buttons, surgical instruments and matches.



THE UNITED STATES AMMONIUM NITRATE PLANT, *Perryville, Md.* *(Atlas Powder Co.)*

A Description of the Manufacture of Ammonium Nitrate by the Double Decomposition of Chilean Saltpeter and Ammonium Sulphate—Phases, Their Control and Application—Plant Operations

UP TO the present there have been military reasons for close secrecy about the Government ammonium nitrate plant at Perryville, Md., which was speedily constructed last spring. It was put into operation on July 20, replacing in about 100 days, with an enormous plant built of concrete, tile and steel, the green fields of a plantation famed since Colonial days for its fine view of the wide waters to the south, where Chesapeake Bay suddenly tapers into the gigantic Susquehanna River. The site was chosen because it offered most ample facilities for receiving great quantities of raw materials such as Chilean saltpeter at port, sulphate of ammonia from the coke-oven region by rail through the uncongested Susquehanna Valley route of the Pennsylvania R.R., coal and abundance of fresh water. Oil of vitriol, the so-called universal chemical manufacturing reagent, has not been listed, because no such intermediary is required for performing the direct cyclic process used in this operation and which was devised by Freeth and Cocksedge,[1] so that the following simple equilibrium is forced to the right, giving sufficiently pure needle ammonium nitrate by the double decomposition of the reciprocal salt-pairs. The common ammonium and nitrate salts of commerce are utilized without making any intermediates such as nitric acid or ammonium hydroxide.

$$2NaNO_3 + (NH_4)_2SO_4 \rightleftharpoons Na_2SO_4 + 2NH_4NO_3.$$

Another process[2] somewhat similar has been described as operated in France, making use of the Solvay ammonium chloride liquor obtained from the familiar salt-ammonia-carbonate process for making sodium bicarbonate according to the reactions:

$$NaCl + NH_4OH + CO_2 \rightleftharpoons NaHCO_3 + NH_4Cl,$$
$$NH_4Cl + NaNO_3 \rightleftharpoons NaCl + NH_4NO_3.$$

The Germans are reported to have substituted the sodium chloride in the Solvay reaction with sodium nitrate and obtained ammonium nitrate liquor[3] directly, but this process could not have become of great importance with them, because of their shortage of crude Chilean nitrate salts. It was thought that the cost of carbon dioxide and lime, together with the manufacture of the accompanying complicated equipment necessary for the performance of the process, rendered this reaction of little use in such an emergency as existed during the days when the U. S. Ordnance Department had to create a munition industry with the greatest speed possible. Furthermore, the bicarbonate crystallized out is contaminated with several other salts and cannot be marketed directly as obtained.

The solubility curves in Fig. 1 indicate the ratio of each of the four salts involved in the equilibrium to 100 parts of water in single solution from 0 to 100 deg. C. In the case of the mixed-salts solutions, the saturation solubilities fall below the respective single solute curves in accordance with the law of the solubility-products of the constituent ions: NH_4, Na, NO_3 and SO_4. Groups 0 and 3 are examples of saturated concentrations which clearly indicate the depression of the ions by the drop in the points 0 and 3, (—, b and c) below the respective curves, Fig. 1, in the NH_4NO_3 — $NaNO_3$ — Na_2SO_4 salt system as actually used in the cycle operation of the sulphate-nitrate process of Freeth and Cocksedge. Besides the three well-known anhydrous, hepta- and deca-hydrous phases of sodium sulphate and the five enantiotropic crystalline phases of ammonium nitrate, the following four double salts exist to complicate matters and give impure yields:

$$Na_2SO_4 \cdot NaNO_3 \cdot H_2O,$$
$$Na_2SO_4 \cdot (NH_4)_2SO_4 \cdot 4H_2O,$$
$$(NH_4)_2SO_4 \cdot 2NH_4NO_3,$$
$$(NH_4)_2SO_4 \cdot 3NH_4NO_3.$$

[1] U. S. Pat. 1,051,097—1913. British Pats. 16,454—1910; 12,401—1915.

[2] Etude d'une Double Decomposition Saline Reversible. Par E. Rengade. Revue général des Sciences pures et appliquées. No. 17-18, Page 489-503, Sept. 1917.

[3] Thomas Fairley D. R. Pat. 97,400.

WASTE SULPHATE CONVEYOR WITH TRUCK LOADING ARRANGEMENTS

In the absence of a temperature-concentration chart showing the stability areas and equilibrium loci of this very complicated polyphase system only a brief account of the five forms of ammonium nitrate and their application in the manufacture of the explosive trinitrotoluene mixture called amatol will be given. A description of the plant equipment and operation will follow. The feature of the plant, the control of the temperature of the crystallizing liquors, will be completely treated in a separate article in a following issue.

Phases of Ammonium Nitrate

The four transition points of the five crystalline phases of ammonium nitrate are at —16, 32, 84 and 125 deg. C. The form existing below —16 deg. C. has no practical application and need not be described in this paper. The needle crystalline form, scientifically named beta-rhombic, is the usual and important salt, being stable from —16 to 32 deg. C. Its density as determined by flotation is 1.725 at 25 deg. C. Needle crystals have the exclusive commercial advantage of not caking into hard masses when stored and can be conveniently handled when the salt has not been allowed to become saturated with hygroscopic moisture. When heated through 33 deg. C., beta-rhombic crystals are immediately converted into alpha-rhombic crystals, a pseudomorph, that is, an aggregate of fine crystal particles of a new individual form but which retain the general external facial appearance of the original needle crystals. If the needles are stirred during heating, they break down into a very fine powder and when stored in the presence of moisture, harden together into a white opaque stone-like mass. The change in form is accompanied by about 3 per cent expansion, the density of the alpha crystals being 1.66. If a block of needle ammonium nitrate is heated and cooled through the transition temperatures (33-31 deg. C.), the permanent expansion sets up voids so that the block becomes spongy. After repeated heating and cooling the block will disintegrate. Because of the tendency to cake into a hardened mass in the presence of moisture, alpha-rhombic crystals are an undesirable commercial form. When a large amount of alpha crystals are allowed to cool, the temperature can be observed to stand at 31 deg. C. for a considerable period. The latent heat of the change from alpha- to beta-

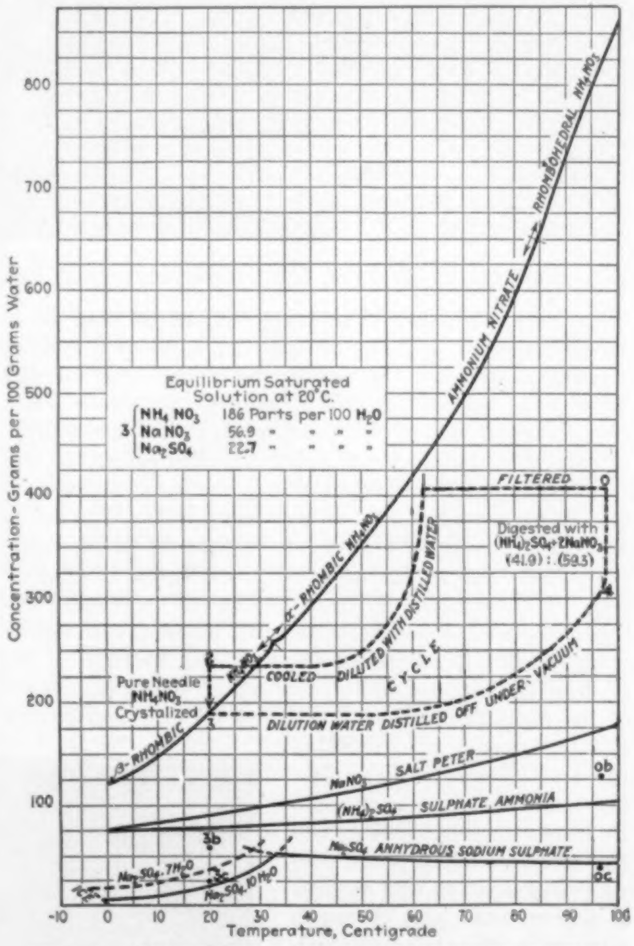


FIG. 1. SOLUBILITY CURVES AND PROCESS CYCLE

rhombic crystals has been determined to be 5 calories per gram, which is a considerable heat quantity in comparison to the low specific heat of such salts.

The transition to the rhombohedral form takes place at 84.2 deg. C. This change is abrupt, not showing a lag as in the previous case from 31 to 33 degrees; furthermore, the transition is not indicated by a distinct change in the solubility curve slope[4] as is shown at 32 degrees in the ammonium-nitrate curve of Fig. 1. When the salt is heated above its melting point, 169 deg. C., and cooled rapidly to atmospheric temperature, it passes directly to the needle phase showing no indication of the existence of or transition through the

CRUDE SALTS UNLOADING SHED AND STORAGE HOUSES

[4]W. Müller and P. Kaufmann, Zeitschr. physikal. Chem. 42,497. 1903.

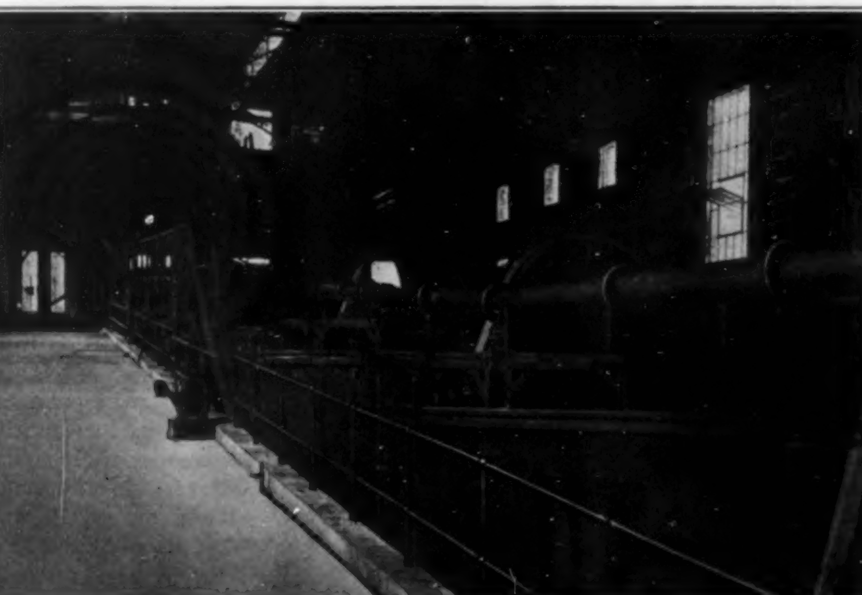
VACUUM FILTRATION DEPARTMENT—ROTARY FILTERS ON PLATFORMS

cent of sodium nitrate with the salt gives a product melting at 120 deg. C. Thus it will be seen that in the presence of these materials, low temperature molten salts fusions are characteristic. Ammonium sulphate usually contains fixed coal-tar bases such as pyridene as well as from 1 to ½ per cent free sulphuric acid. The organic base is an undesirable impurity in amatol and the acid augments the very corrosive action of the concentrated nitrate salts on the equipment. Therefore sufficient soda ash to give a slight alkaline reaction is added so that both the pyridene is free to be volatized during the heating in the digestors and the liquor has as weak an acidic action as is possible with such a weak base as ammonium. No

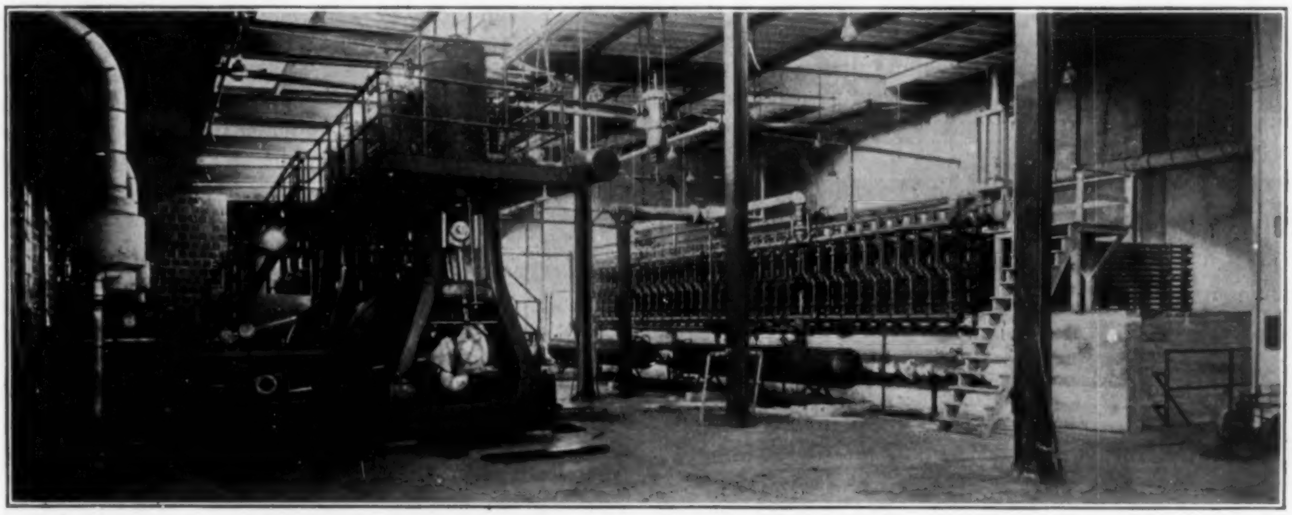
intermediate phases. The transition at 84 deg. C. is accompanied by a slight contraction in volume and an absorption of heat, the density becoming 1.69 and the latent heat amounting to 5.33 calories per gram. The rhombohedral and alpha-rhombic states of ammonium nitrate with their accompanying physical properties are very important in the manufacture of the explosive amatol (80 per cent NH_4NO_3, 20 per cent TNT). The latent heat of 4 grams of ammonium nitrate is 21.53, while the latent heat of fusion of trinitrotoluene is slightly less, 21.4 calories. Direct application is found for these balanced latent heats in shell loading, the amatol being heated to above 84 deg. C., and because of its reserve in latent heat of transition the temperature of the mass does not cool to below 84 deg. and during the lag period of transition the amatol remains in a plastic condition[6] long enough to be loaded into the shell. The fine powdery alpha phase prevents segregation and assures a disseminated and thorough mix with the trinitrotoluol, producing a homogeneous amatol. When heated through 125 deg. C. the cubic system appears, the fine particles of which cling together in an almost collodial glue-like mass. This phase is one to be strictly avoided in ammunition work and prohibits the use of steam coils in contact with the salt. One per cent of water will lower the melting point of the salt from 169 to 159 deg. C., while 20 per

[6]Melting points TNT, 2:4:6, 80.8°C; 2:3:4, 112°C; 2:4:5, 104°C.

average analysis of Chilean saltpeter can represent the commercial conditions found in practice, for the caliche beds vary among themselves considerably as well as the methods of leaching them and crystallizing the more or less refined salts. The principal sodium salt impurities are chlorides, sulphates, borates and iodides. Potassium is the most important as well as variable foreign base present, good caliche earth often analyzing from 25 to 30 per cent $NaNO_3$ and from 3 to 5 and even 10 per cent KNO_3, with a result that extracted salts are found with minimums around 2 per cent KNO_3 and maximums up to 8. Ordinarily the percentage of sodium nitrate in Chilean saltpeter is in the lower nineties. Before the crude saltpeter can be used in the double decomposition process, it



DIGESTOR DEPARTMENT—BATTERY OF EIGHT 900-CU.FT. DISSOLVERS IN GRAVITY CIRCUIT



CARRIER AIR CONDITIONING DEPARTMENT—COMPRESSORS AND COOLERS

must be thoroughly refined so as to prevent as far as possible the accumulation of foreign salts in the nucleus solution and especially remove the potassium salts, which have the property of crystallizing out with the needle ammonium nitrate, forming a highly undesirable impurity in amatol. Any alkaline earths that may be present will be precipitated as carbonates by the initial addition of soda ash and will pass out of the nucleus solution at the filters with the anhydrous sodium sulphate precipitate and other foreign solids. The halogen impurities are of minor importance, and so do not seriously affect the reaction. Next to potassium, the most trouble was found in keeping the solution cleared from pieces of bags, cordage, etc., which clogged the pump inlets.

Organization of Plant

The Atlas Powder Co. acted as agent for the Ordnance Department and installed an experimental plant where the details regarding apparatus, capacities and design ratios for carrying out the process were determined as well as possible. This was of prime importance in securing and training an experienced staff during the period in which the plant was being constructed so that no time would be lost in starting the works as soon as completed.

The process was operated continuously in three 8-hour shifts. A total of one hundred executives and technical men and 1800 mechanics and laborers were required in the operation. Mr. Frank S. Pollock, plant manager, was in charge of manufacture and plant. Among the personnel, the following should be mentioned:

Major A. S. Sinclair, contracting officer, U. S. O. D.
Mr. E. E. Bard, assistant plant manager.
Mr. J. T. Power, in charge of construction.
Dr. Guy C. Given, chemical research.
Dr. Frederick Bonnet, chief chemist.

Power and Water Plant

The Fred T. Ley Co. of Springfield, Mass., built the entire plant and are to be commended for their speedy and excellent construction, especially of the twelve 830-hp. boiler power plant in the record breaking speed of 64 days. A 10,000-hp. B. & W. Stirling boiler installation equipped with Westinghouse electric stokers, 4500-ton capacity overhead coal bunkers, two 210-ft. hollow tile stacks, steel derricks with clamshell coal buckets and three 1000-kw. condensing turbo alternators, together with forty miles of steam and water pipe lines from 30-in. diameter down make a million-dollar job alone, and in ordinary times might be considered as a large undertaking. However, compared to the expenditures for the entire plant, the power department cost about 7 per cent.

Water was obtained from the Susquehanna River by a main pump house having a capacity of 30,000,000 gal. per 24 hours. A special sluiceway had to be sheet piled and excavated to deep water so as to obtain a clear flow to the pump. Ninety-five per cent of the water was used direct for cooling purposes in the plant and was exhausted into Chesapeake Bay through the sewerage system, while the remaining million gallons was refined by the usual alum filtration and liquid chlorine process and used in supplying the boilers and potable mains throughout the plant and village. About 80 per cent of the boiler steam was consumed directly in heating the digestors and evaporators and 10 per cent each in the water pumping station and in the electric power house, which supplied the lighting system and the motors throughout the plant used in driving pumps, agitators, belt and bucket conveyors, compressors, fans, rotary filters, etc.

Chemical Plant Layout

The chemical plant consists of two similar independent units of equal capacity, with the soda purification, distilled water and liquor storage, centrifugal and finished product houses in common. The solid materials were transported on belt conveyors through tunnels. Stationary and portable bucket conveyors were used for elevating the materials to the crude storage piles and charging the belts and weighing machines. The buildings were constructed of hollow tile and concrete so as to reduce fire risks and furnish heat insulation for the process. As ammonium nitrate has a disintegrating action on concrete, all floors likely to come in contact with this material are tiled, especially those in the liquor filtering and pumping departments. The buildings were roofed with 3-ply everlastic laid on a yellow pine deck attached to steel beams.

A standard gage railroad track makes a complete loop around the plant, double tracks passing on both sides of the raw material stores and under the finished product bins, allowing ample unloading and loading space, and, with the sidings, giving a 5½-mile yard within the works.

The production capacity of finished ammonium nitrate of 94 per cent purity and 2 per cent moisture content was close to 300 long tons per 24 hours. This required the handling of 350 tons of sodium nitrate, 300 tons ammonium sulphate and 4½ tons of soda ash per day.

Crude Storage Houses

As one enters the gates, the odd ten-sided structures conforming to the outlines of piled materials, with incline conveyors climbing up their pyramidal roofs, first excite one's curiosity. The two largest, with "Crude Soda" painted on their concrete walls between the bracings, hold around 1000 carloads of saltpeter when full. The smaller octagon-shaped stores marked "Sulphate" have much less capacity because ammonia is a domestic material and need not be carried in such large stocks. The storage spaces for soda ash and refined soda are also of modest size and for evident reasons, the latter being a governor on the soda refinery and carrying sufficient supplies to tide over minor interruptions in the previous operations.

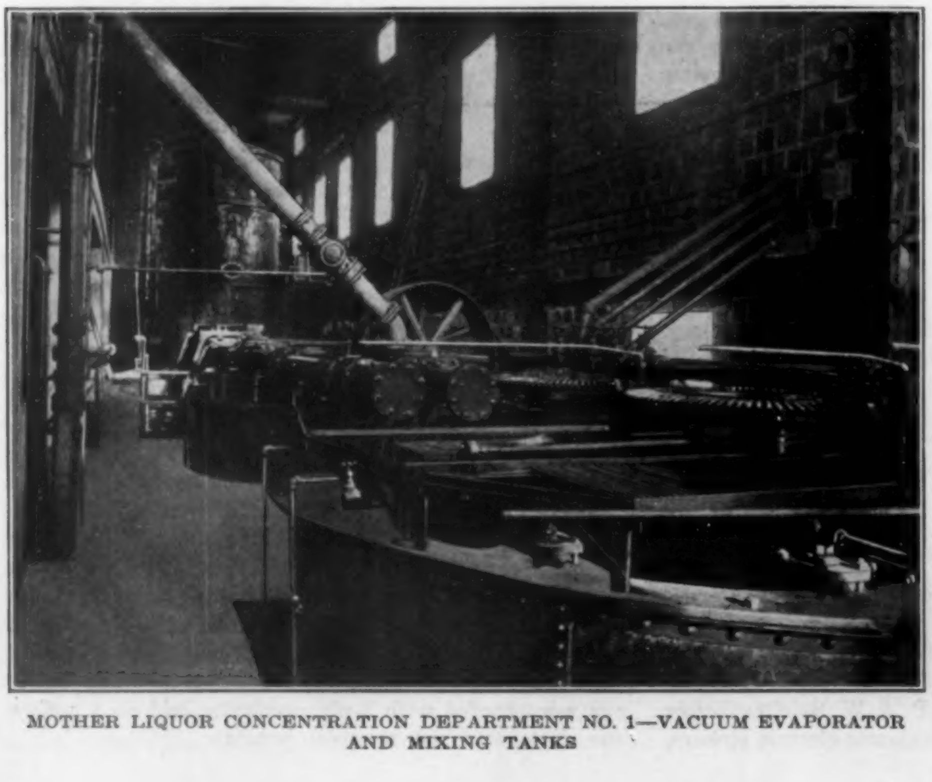
The empty nitrate sacks are sent to the bag washing department, where they are mechanically freed from as much soda as possible in a tumbling reel and then conveyed counter-currently through a simple rectangular box washer, passed through a wringer and dried in a hurricane Philadelphia drying machine. The feed water is so adjusted as to furnish a saturated solution of nitrate which is piped to the saltpeter purification department storage liquor tank.

The crude sodium nitrate crystals were fed directly into a Dorr six-deck washing classifier set at a 2½-in. pitch, which agitated and conveyed the crystals up through the down-coming saturated nitrate solution from the bag washing department. A sufficient extraction of the potash and chloride content was obtained with the exhausted wash liquor carrying about 34 per cent $NaNO_3$ and 28 per cent KNO_3. While quite successful in the operation, two important difficulties were experienced, of which the accumulation of fines at the base of the classifier was very serious, overloading the mechanical parts of the machine and making it necessary to reinforce points that were over-stressed. This was counteracted by discharging the fines at the base at intervals. The other difficulty was to free the crystals from sufficient mother liquor to break their coherence. This was accomplished by riveting a three-foot apron of eighty-mesh punched sheet iron at the crystal discharge end and extending the rake sufficiently to convey the material over the screen. It was intended to apply suction and thus pull the adhering wash liquor off. An Oliver sand filter was used successfully during the operation of the plant for preparing the crystals for conveying to and storage in the "Pure Soda" building.

The wash liquor was concentrated in two large Buflovak vacuum evaporators and the several salts crystallized in fractions. This department was being developed by the research department and had not reached a permanent manufacturing basis, but undoubtedly pure potash salts would have ultimately been made on a large scale[6].

Digestion Departments

The two batteries of 900-cu.ft. Buflokast iron horizontal cylindrical digestors are housed in separate buildings between which the mother liquor storage tank house intervenes. Each battery was installed with eight digestors, the combined contents of which was 450 tons of solution per unit, the flow of which was obtained by an eighteen-inch drop in level between digestors. During the operation it was found that numbers five, six and seven could be dispensed with. The digestors were connected by both overflow open conductors and underfeed pipes. The materials were added continuously to number one at a normal rate of 500 pounds per minute through automatic weighing machines. The salts are thoroughly agitated with the hot nucleus solution. Steam is blown in directly to obtain rapid fusion. Samples are taken constantly and the end of the reaction is determined by the absence of sulphate in the sublimate obtained from volatilized ammonia salt vapors upon fusing the dehydrated liquor.



MOTHER LIQUOR CONCENTRATION DEPARTMENT NO. 1—VACUUM EVAPORATOR AND MIXING TANKS

[6]Process for Separating $NaNO_3$-KNO_3, Given and Barteaux, U. S. P. 1,294,788.

Great care must be taken in preventing the pipe lines from becoming frozen or blocked with solidified salts, and when a pump is stopped for repairs the line must be blown with air or steam immediately and flushed with hot water to remove any accumulated solid crusts. The greatest trouble experienced in the operation of the plant was with the pumping equipment. The hot concentrated nitrate salts probably enjoy the record for corrosive efficiency, often demonstrating this by putting a new pump out of business in a few hours of use. The pump packing found most successful was asbestos graphited braid which had been slightly lubricated with soap, which probably reacted with the liquor, giving a modification of the so-called nitrated-oil rubber. As more or less bagging, rags and rubbish seemed to get into the liquor in spite of many precautions, it was not thought safe to use silicon iron, which is very brittle and apt to break when jammed suddenly. However, a screen trap could have supplied a cure for this trouble and undoubtedly chemical iron ware would have been a boon to the pump man.

The liquor pumps did not enjoy a monopoly of the pump troubles, for the vacuum apparatus pulled a fine liquor spray into its headers which solidified and acted most effectively, making frequent clean-outs necessary which were humorously referred to by the men with some thought of their rival at Muscle Shoals as their "Air Nitrate Plant." This trouble was eventually overcome by greatly enlarging the size of the exhaust mains with a consequent decrease in the gas velocity to a point where no spray was carried to the cold zones.

The liquor was filtered with Oliver continuous vacuum rotary filters. Extra ports were added so as better to distribute the suction and clearing steam back pressure. Cotton, monel metal and wool fabric were used, the former being immediately destroyed, the second lasting about two weeks at a cost of $400 per filter and the third giving the cheapest service, lasting one week at a cost of $67 per machine. A quarter-inch mesh aluminium-wire screen was applied to the cylinder, the wool placed over it and wound spirally with heavy monel wire, six revolutions to the inch. Both the aluminium and monel metal had given permanent service without replacement. As about twenty Olivers were in operation, the filter fabric was an important cost. The support received by the wool determined its life, for as soon as bulges were formed between the monel spiral, the friction of the scraper soon wore a hole through the fabric and made its immediate removal necessary. The anhydrous sodium sulphate crystals removed from the filters were mixed with distilled water, refiltered and dumped to the waste belt conveyor. As the hydrous phases begin to form at temperatures below 33 deg. C., considerable trouble was experienced with rebuilding crystals, which grew tenaciously to the idler rolls, the belt and everything with which they came in contact, somewhat after the manner of freezing water. While the most excellent service was obtained from the nitrate, sulphate and carbonate conveyor systems in the other parts of the operation, dump cars or even hydraulic conveying perhaps would have been more suited to this department. At the end of November, the sulphate dump contained about five hundred carloads of salt, which carried a small content of nitrates. Among the illustrations a view is given of the waste conveyor and trestel incline, which is designed so that the salt coming from the main cross-tunnel belt conveyor serving the two digestor liquor filter departments could be either dumped into trucks or carried to the storage pile.

Upon consulting the cycle graphically charted in Fig. 1, it will be seen that the filtrate, if simply cooled to 20 deg. C., would be supersaturated with all three salts. In European practice, several methods of separation have been worked. Roth[7] claims to get good yields by fractional fusions of the anhydrous salts. Lennox[8] sublimates under vacuum and Craig[9] carries over the ammonium nitrate vapor with ammonium gas. As there is a wide variation in solubilities, fractional crystallization commends itself. However, where efficient vacuum evaporating apparatus is used, the best method of refining is believed to be had by simply adding sufficient water to the liquor to bring the sodium nitrate down to 3b and the sulphate to 3c as shown in Fig. 1. The cycle shown illustrates the character of the process outlined, but does not represent the actual practice. Since

[7]D. R. Pat. 48,705, 53,364 and 55,155.
[8]D. R. Pat. 96,689.
[9]D. R. Pat. 92,172.

CRYSTAL DRYING DEPARTMENT—FOUR BATTERIES OF TOLHURST CENTRIFUGALS

the initial hydration of anhydrous sodium sulphate produces the heptahydrate[10] the point 3c will be located between the hepta and deca curves. However, dilution is always based on the ordinate 3b — 0b, since the sodium nitrate solubility increases with higher temperature and the sulphate decreases. The NO_3 ion of the very soluble ammonium nitrate depresses the solubility of the saltpeter to 0b, while the Na ion of the nitrate depresses the sulphate down to 0c. In determining the required amount of water for dilution, crystal tests were run for the sodium salts at the mixing tank, which were continuous, the ratio of the two liquid feeds being gaged by calibrated Pelton nozzle orifices.[11]

Crystallization Departments

The crystallizing building of each of the plant units was divided into four sections, each of which was equipped with fifteen rows of eight-deck 40-cu.ft. iron pans. As about 120 pans were filled per hour, all the parts took care of the production of an 8-hr. shift. In order to prevent the temperature from falling below 20 deg. C., where the sodium salts would be crystallized out, and yet obtain a maximum yield of ammonium nitrate needle crystals, it was necessary to install an air conditioning plant with each of the pan rooms. Four Carrier automatic temperature and humidity regulating systems were installed, where the crystallization was carried out under controlled conditions at 20 deg. C. Full treatment will be given to this operation in an early issue.

When the ammonium nitrate content of the mother liquor in the crystal pans is sufficiently low, the plug is pulled and the liquor allowed to drain off into a pipe line leading to the mother liquor storage building, located between the digestor buildings, where it is pumped into one of the sixteen 3000-cu.ft. tanks located there. Three 900-cu.ft. Buflovak vacuum evaporators are in each digestor building, by which the spent mother liquor is concentrated to nucleus liquor concentration to be returned to the next cycle. At the same time, the condensed vapors furnish distilled water for subsequent diluting and washing.

The drained crystals are raked from the pans to a belt conveyor, which charges them into Tolhurst centrifugals. The moisture content is quickly reduced to the 3 per cent maximum and the finished product discharged from the bottom to a belt conveyor, which carries it to elevated storage bins to be loaded into box cars by gravity upon shipment. Thirty-two centrifugals are used, eight to the crystallizing room, or one to each fifteen pans.

Due to the sudden cessation of the manufacture of explosives, this plant was closed after almost as brief an operating period as it took to construct it. However, it met in excess all the demands made upon it and is a far better investment than commonly can be made by the War Department. It cost less than half the usual expenditure for a battleship and is capable of abundantly rendering more than its equitable share in the national business of war. Furthermore, should war go out of style, this plant can be readily converted to peace-time pursuits.

[10]Loewel, Ann. Chem. Phys. 49, p. 50, 1875.
[11]The formula is: $Q = 99d^{1.98} H$, Q = quantity lb., d = diameter orifice, H = heat in feet

Reclaiming Steel Works and Industrial Wastes

By Francis Hall

FUNDAMENTALLY wastes may be divided into two classes—waste of materials and waste of effort. In what follows, material wastes only are to be treated.

The principle of saving of wastes is almost as old as the hills. It was dwelt upon at length in the Holy Scriptures and was practiced in ancient times. No doubt, owing to the greater simplicity of life and industry in earlier times, more stress was laid upon savings and the control of wastes was easier. In any event, the salvage and control of wastes are anything but a simple matter at present, whether they be household, governmental or industrial.

As the volume of business and the magnitude of individual undertakings have increased, the facilities and the means of every kind have increased in size and complexity. Higher grade products and higher efficiency of production have frequently increased rather than lessened the amount of material classified as primary wastes. At all times, in America particularly, the general slogan has been "production," "get out the product." With works' executives, superintendents, foremen and leaders all constantly absorbed in getting greater production, it is not strange that the humble but highly profitable task of utilizing any accruing wastes to the same degree of efficiency should be neglected.

Importance of Saving in Peace Time

Fundamentally, America is not a saving country. As practiced by the French, saving and reclaiming almost every available bit of waste, as well as money, are generally unknown here. If saving is important in war times as a national necessity, it is doubly important in peace in order to preserve the national ease, comfort and standard of living at times when the lowest-priced good products command the market. In steel, munition, engineering, chemical, mining, and in general in all other industries, the fundamental ability of a plant to get the most out of its materials is largely dependent upon a personal equation—not of its executives, but of its workmen, down to the lowest rank. Most executives realize this, but somehow it has seemed difficult to compass effective salvage of materials when men and leaders devote unstintedly their time and effort to attaining a splendid volume of production. Moreover, neither the executive, foremen nor workmen have, as a rule, any clear personal idea of what it means to save their own, much less save somebody else's (their employer's) waste material. It is all waste or junk to them, fit for the dump or ash heap and therefore not worth bothering their heads about, so long as it is gotten out of the way promptly.

Most Americans are familiar with the slogan of the great packing industry, who claim to be saving and utilizing the entire pig, beyond the squeal. This seems literally true, and in fact is forcibly brought out by the recently issued report of one of the large packing concerns showing their entire yearly profit to have been made by utilizing to the last degree the by-products formerly wasted.

It is unfortunate that the same may not be said of the majority of other American industries. The surest sign of the lack of waste-salvage is the scrap pile, and this applies, paradoxically though it may seem, to the steel industry. For while scrap enters largely into the manufacture of steel, the character and makeup of the scrap stock-piles of a steel plant provide a sure indication of the degree of wastage occurring in the department or outside industry where it originated.

The most complicated problem of salvage so far undertaken is presented by the modern fully-integrated steel works with production from mine and scrap to finished product, be it principally armor plate, armor piercing projectile, shrapnel, high powered ordnance, turbine elements, car wheels, forgings, shafting, sheet, ships, bars, plates, rolls—all finished or green materials. Why this is true may be easily explained when it is understood that the large combined steel and ordnance works require nearly every branch of modern engineering and technical skill, together with the accompanying vast flow of both raw and finished material and innumerable kinds and classes of standard and special equipment and tools. In addition to the primary or producing departments, such as blast furnace, open-hearth, blooming mills, rolling mills, bar mills, sheet mills, rail mills, tire mills, steel foundry, forge shops, press plants, annealing plants, oil tempering plant, armor tempering plant, projectile plant and ordnance plant, consider that there may be necessary from 30 to 75 separate and distinct auxiliary departmental organizations, each demanding a constant flow of more or less specialized material and equipment and a consequently inevitable outgo of used, partly used, good, new, worthless and indifferent scrap, waste material and equipment.

Money in the Junk Pile

Consider this and the multitude of real facts about such a plant one can find by tedious, persevering and painstaking watchfulness and personal investigation, and the most recalcitrant doubter will become convinced that there must be something in that specialized industry that maintains and waxes rich a junk man in every little town. He will find that rubber is rubber, burlap is burlap, leather is leather, and lumber, asbestos, pipe fittings, electrical parts, pulleys, blanks, gears, bushings and so on almost to infinity are each what they are —scrap, good or fair, and each item capable of yielding dollars like finding the money by a simple commonsense treatment. He will also realize that by reducing the handling of current waste material by regularly and systematically collecting, disposing and utilizing it at some other place in the works as far as possible he can cut his costs of operation to where a low-priced contract can be taken now and then that will "keep the wheels rolling." He will find that those short (but otherwise good) bars, tubes, plates, rolls, castings, forgings, ingots, tool steel or merchant bar are just what some engineering, shipbuilding, railroad, electrical or machine works may be dying to get and would pay a round price for—a price that will make melting-up and thereby destroying the real value look more than criminal, besides adding a nice fat look to the profit side of the balance sheet.

He will, at length, learn the simple maxim that "a penny saved is a penny earned" just the same in a steel plant or aircraft or metallurgical works as in his own personal affairs.

It is not only patriotic, it is common sense, to save and utilize, to reclaim all available material of every kind, to dispose of it regularly and profitably, to eliminate entirely in America for all time the costly hideous miscellaneous scrap piles. It is the highest type of war preparedness or industrial peace preparedness that spells the real quality of invincibility. In extenuation of the lamentable condition as to nation-wide wastes in which the United States has by this war discovered herself may be advanced the freedom from real want and the universal easy-living conditions so long continued as to dull the usual sense of caution.

It may be safely said that no modern specialist is required to be as versatile and widely technically informed as in the new vocation of industrial reclamation engineering. Initiative, imagination, decision, resource and ingenuity must be available to the last degree in making the big and profitable undertaking such work will become in almost any American works. The general principles involved in the handling of scrap and wastes profitably on a large scale and in the variety found in a large steel or industrial plant are simple enough. Getting the business going promptly and in a way to pay for itself from the start is a task which will take all any normal being has in him.

Philadelphia, Penn.

Commission to Settle Losses on War Minerals

Former Senator J. F. Shafroth of Colorado, Philip N. Moore of St. Louis, Mo., and former Representative M. D. Foster of Illinois have been appointed by Secretary of the Interior Lane as members of the commission that will have charge of the payment of the losses incurred by mining men in the production of manganese, chrome, pyrites and tungsten for war purposes.

During the war the Interior Department, the Emergency Fleet Corporation and the War Industries, War Trade and Shipping Boards insistently urged the mining men to produce these materials to supply the urgent needs of the nation for war purposes. When the armistice came, these mineral producers, as a result of their response to the demands of the Government, had on hand ready for delivery quantities of these materials, for which there was no peace-time market.

Congress set aside $8,500,000 to meet claims for these losses, which must be filed within three months after the passage of the act. The law provides that the claims must have been incurred between April 6, 1917, when the United States went to war, and Nov. 12, 1918, when the armistice was signed. The Secretary of the Interior is charged in the act with taking into consideration and charging to the claimant the market value of the minerals on hand Nov. 12, 1918, and also the salvage or usable value of the machinery that was installed to produce these war minerals.

Mr. Moore is a former president of the American Institute of Mining Engineers and a well known engineer.

Mr. Shafroth was a member of the Senate Committee on Mines and Mining of the Sixty-fifth Congress and Mr. Foster was chairman of the House Committee on Mines and Mining.

Practical Considerations in Ammonia Leaching of Copper-Bearing Ores

Description of Plant Installation and Operation—Leaching Tanks: Plate Joinings, Filters and Inlets—Piping and Pumps—Evaporators—Details of Operation: Charging and Extracting Ore, Chemical Control—Cost of Leaching: Labor, Power and Ammonia

BY LAWRENCE EDDY
Formerly Mill Superintendent, Kennecott Copper Corp., Kennecott, Alaska

THE engineering profession is already acquainted with the successful extraction of copper from its ores by an ammoniacal solution. In the year just past a number of improvements, mostly of a mechanical nature, have been worked out at the plant of the Kennecott Copper Corporation at Kennecott, Alaska. These developments are presented here, with some other points of interest to practical metallurgists.

The leaching plant at Kennecott is designed to treat the tailings from a "wet" concentrating mill, and has handled 450 tons of mill tailings per 24 hours, average of one month's run. The maximum capacity, however, with the equipment as herein described, is over 600 tons per day. Scarcity of ammonia and other abnormal conditions have reduced the tonnage to the lower figure.

The ore as mined contains copper in the form of sulphides, mostly chalcocite with some covellite, and also oxidized copper in the form of the carbonate malachite. The gangue is limestone. There is no native copper metal present. Treatment of the ore on concentrating jigs and tables gives a very good recovery of the heavy sulphides, but the malachite is inclined to be porous and flaky, and is of nearly the same specific gravity as the limestone, hence 40 per cent of this copper escapes from the jigs into their tailings. The ordinary acid leach is not suitable to recover this copper because it also attacks the limestone. Flotation would entail more grinding and the dubious problem of sulphidizing.

Under these circumstances ammonia leaching was adopted, and the process has now been cheapened so as to permit its application to a wide range of ores. Ammonia will not recover any gold or silver values, or any copper sulphides unless roasting is resorted to. With oxidized copper having the general form $CuCO_3 \cdot Cu(OH)_2$ a dark blue solution is formed which on heating gives off NH_3 vapor, CO_2 gas, and deposits a heavy black powder consisting mostly of CuO. The writer is not prepared to give the chemical formula of the blue copper-ammonia solution; he believes it to be a mixture of cuprous and cupric combinations, and that the proportions differ under different conditions. Table I shows the character of the mill tailings as they reach the leaching plant. Copper sulphides are also present in addition to the oxidized minerals to the extent of 0.20 per cent, but, being inactive in the leach, they are considered as part of the gangue. Roasting would not pay as so small a quantity of sulphides would be recovered.

BRIEF COMMENT ON FLOW DIAGRAM

Item 1. Mill tailings are leached just as they come from the jigs and tables without any further crushing. They must be deslimed, however, because the slimes have the bad effect of cementing the ore together in the leaching tanks, forming a hard mass that is not easily penetrated by the leaching solution or the steam wash. It is also much harder to excavate the leached tails unless they are cleaned of material finer than 200 mesh. Desliming apparatus consists of two esperanzas 5 ft. wide and 30 ft. long. One only is in use at a time, the other being a spare. Table II shows the character of the deslimed ore. Most of the minus 200 mesh material has been removed, but all the fine sands are left in the ore. At present these slimes are run to waste, pending further developments in a process for their treatment. An extraction of 80 per cent can be obtained from the deslimed ore. Screen tests show that the best results are had with finer sizes, plus 60 mesh material giving the best extraction. However, the recovery from the coarser sizes does not drop enough to warrant putting

TABLE I. SCREEN TEST OF MILL TAILINGS

Size	Per Cent Weight	Assay Per Cent Ox. Cu	Lb. Ox. Cu in 100 Lb. Ore	Ox. Cu Per Cent Distrib.
+ 12 mm.	5.6	0.69	0.0386	3.8
+ 9 mm.	17.0	0.71	0.1208	12.0
+ 6 mm.	24.5	0.75	0.1839	18.3
+ 2 mm.	27.6	0.79	0.2180	21.7
+ 1 mm.	5.6	0.90	0.0504	5.0
+ 40 mesh	4.1	1.20	0.0492	4.9
+ 60 mesh	1.9	1.43	0.0272	2.7
+100 mesh	2.7	1.41	0.0381	3.8
+150 mesh	1.3	1.20	0.0156	1.6
+200 mesh	1.5	1.45	0.0217	2.2
−200 mesh	8.2	2.94	0.2411	24.0
	100.0		1.0046	100.0

TABLE II. SCREEN TEST ON LEACHING PLANT HEADS

Size	Per Cent Weight	Assay Per Cent Ox. Cu	Lb. Ox. Cu in 100 Lb. Ore	Ox. Cu Per Cent Distrib.
+ 12 mm.	6.0	0.69	0.0414	4.7
+ 9 mm.	18.1	0.71	0.1286	14.7
+ 6 mm.	26.1	0.75	0.1959	22.4
+ 2 mm.	29.4	0.79	0.2321	26.5
+ 1 mm.	6.0	0.90	0.0540	6.2
+ 40 mesh	4.4	1.20	0.0528	6.0
+ 60 mesh	2.0	1.43	0.0286	3.3
+100 mesh	2.9	1.41	0.0408	4.7
+150 mesh	1.4	1.20	0.0168	1.9
+200 mesh	1.6	1.45	0.0232	2.6
—200 mesh	2.1	2.94	0.0617	7.0
	100.0		0.8759	100.0

TABLE III. SCREEN TEST OF LEACHING PLANT TAILINGS

Size	Per Cent Weight	Assay Per Cent Ox. Cu	Lb. Ox. Cu in 100 Lb. Ore	Ox. Cu Per Cent Distrib.
+ 12 mm.	6.0	0.21	0.0126	6.1
+ 9 mm.	18.1	0.18	0.0326	15.7
+ 6 mm.	26.1	0.18	0.0469	22.7
+ 2 mm.	29.4	0.19	0.0558	26.9
+ 1 mm.	6.0	0.19	0.0114	5.5
+ 40 mesh	4.4	0.25	0.0110	5.3
+ 60 mesh	2.0	0.28	0.0056	2.7
+100 mesh	2.9	0.28	0.0081	3.9
+150 mesh	1.4	0.29	0.0038	1.8
+200 mesh	1.6	0.32	0.0051	2.5
—200 mesh	2.1	0.68	0.0143	6.9
	100.0		0.2072	100.0

in a crushing plant, especially since it would entail a still greater slime loss.

Item 2. A 300-ton storage bin is installed to permit of short shut-downs in either mill or leaching plant without inconvenience to the other.

Item 3. The ore is fed from bin gate to an elevator by a 32-in. "apron" feeder; it is elevated to the top of leaching tanks and conveyed by a chain-scraper to the charging doors on the tops of the leaching tanks, into which it drops by gravity. The resulting cone of ore is leveled off inside the tanks by revolving the excavator mechanism backward, and by hand shoveling. Rate of charging tanks is about 600 tons per 24 hours.

Item 4. It is to be understood that processes 4 to 10 are applied to the ore without transferring it from one tank to another. The order in which each step of the process occurs is from top to bottom of the chart. There are eight steel leaching tanks constructed as shown in Fig. 2 which are charged and put through these proc-

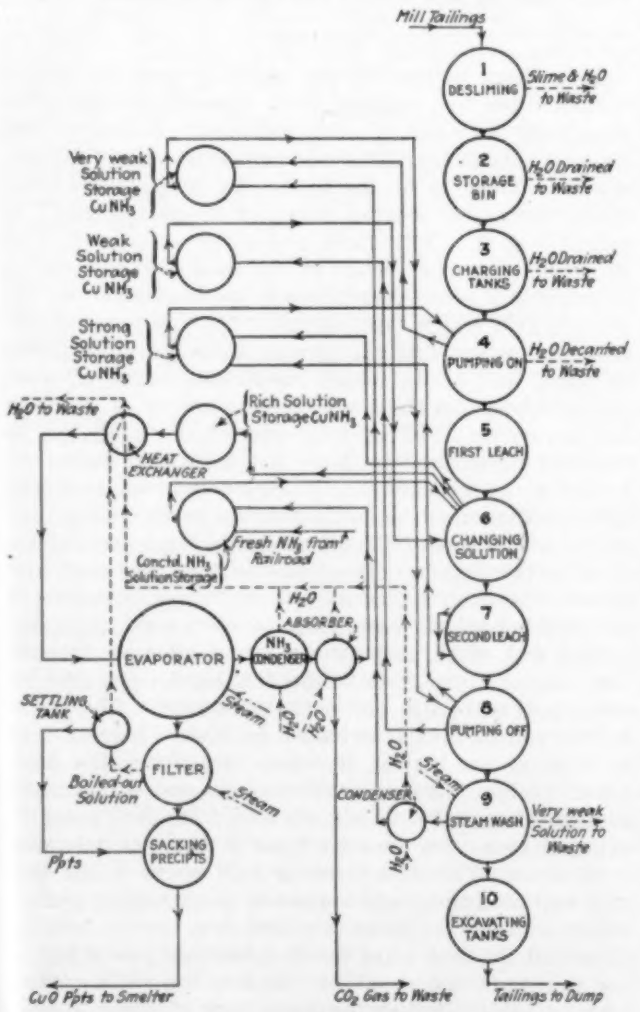


FIG. 1. FLOW DIAGRAM

esses in rotation. Process 4 requires about eight hours, during which the lixivant is pumped into the bottom of the tank and rises up through it. This displaces the moisture contained in the ore upward to the top of the tank, which is still approximately 5 per cent of the dry weight. Part of this can be decanted off the top of the charge to waste as it rises above the incoming ammonia solution, while part becomes mixed with ammonia and is decanted into the weak-solution tank. The remainder is left in the ore, where it dilutes the leaching solution.

Item 5. The ammonia solution is allowed to stand on the ore for 12 hours, without any agitation.

Item 6. A portion of the first leaching solution, approximately saturated with copper, is pumped from the bottom of the leaching tank; at the same time an equal volume of concentrated ammonia, together with some weak copper-ammonia solution, is pumped on the top of the charge.

Item 7. For 30 hours the leaching solution is circulated through the charge by a centrifugal pump which draws the solution from the bottom and discharges it on the top of the charge.

Item 8. Having dissolved all the copper that will go into solution in 30 hours, the leach is now drawn off from the bottom of the charge and transferred to the storage tank for strong copper-ammonia solution; at the same time 20 or 30 tons of weak solution or "wash" are pumped to the top of the charge and allowed to trickle down through it so as to wash out the strong leaching solution.

Item 9. Steam is turned into the top of the tank for about 12 hours, so that it heats the entire charge. This vaporizes any ammonia left in the ore, the weak ammonia vapor passing out of the tank through the drain pipes in the bottom and being recovered in a special condenser, from which it is transferred to the weak-solution storage tank. When the ammonia content of this condensate has fallen to 0.45 per cent, the wash is considered finished and the steam turned off.

Item 10. The doors in the bottom of the tank are opened, which allows the tailings to run out on a conveyor belt and thence to the tailings dump. Less than half of the charge runs out by gravity; the rest is excavated by means of a number of scrapers that revolve about a central shaft and are fed down through the tank by means of an automatic feed screw. Some of the tanks are not yet equipped with this excavating mechanism, and in them a light "slip scraper" is used, guided by hand and pulled by a small hoisting cable working through the top door of the tank. This device is unsatisfactory because a great deal of time and valuable cooling water must be expended before a man can get into the tank to guide the slip. Formerly all tanks were excavated by hand shoveling at a cost of about 11c. per ton.

The Leaching Tanks

More particular comment will now be made on the special appliances used. Fig. 2 is a sectional view of one of the leaching tanks, of which there are eight. The incoming ore was formerly distributed over the tank by means of a rotary feeder in order to prevent segregation of the finer particles. Recently this has been found unnecessary and now the ore is simply dumped into the tank through one of the top doors and leveled off. This method of charging gives a light porous bed of ore which is easily penetrated by the solutions. It is advisable to level off each charge carefully to exactly the same depth so that identical volumes of leaching solution will always just submerge the ore. Otherwise costly irregularities in the operation of the plant will ensue, and the capacity of the storage tanks will be taxed by a large amount of idle solution.

While the tank is being charged and during the interval between charging and the application of the first leaching solution, a considerable quantity of water seeps

out of the ore and is allowed to escape by unscrewing drain plugs in the bottom of the tank. If this water were left in the ore it would dilute the leaching solution, and eventually would have to be boiled out of the system in the evaporators at a considerable expense for steam. Therefore this drainage is important, and should be encouraged as much as possible by hurrying other processes to allow a maximum interval for drainage. Plugs are used here because no valve or cock has been found that will remain tight more than a few weeks. Where lines run from one tank to another a little leakage through the valve will cause no loss of solution, and an ordinary all-iron gate valve is perfectly satisfactory, but all pipe ends that lead from the system must be protected by plugs.

The tanks themselves are made of single-lap riveted steel plate about $\frac{5}{16}$ in. thick. It is well to construct the dome top with a short radius so as to furnish added strength against suction, since at times during the steam wash, a vacuum is induced, due to too rapid condensation of the steam, that will buckle a weak top with disastrous results. The same thing occurs when a careless operator pumps solution out of the tank without opening a relief valve on top of the tank. In opposite effect, too much steam builds up a pressure that will cause the flat bottom to bulge and leak badly at about 5-lb. gage. All these difficulties can be obviated by a good safety valve set for small differences both of pressure and vacuum. Such a device, made entirely of iron for ammonia service, has not been found on the market and must be made to order. Vapor pressures as mentioned above are all measured by a mercury manometer.

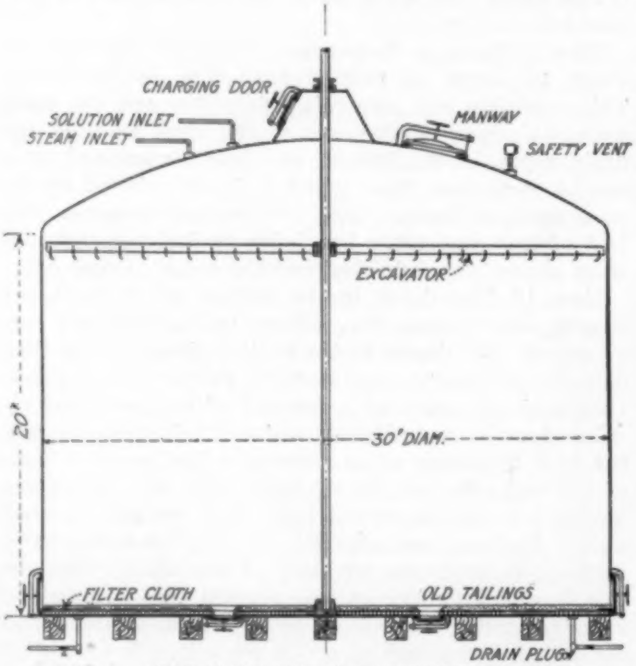


FIG. 2. SECTIONAL VIEW OF LEACHING TANK

Leaks in Tanks a Large Expense

Due to alternate heating and cooling, and to accidental deformations due to excessive pressures, these leaching tanks soon leak at the seams, especially around the bottom, where the pressure is greatest. Recaulking is only a temporary relief, and often leaks come at points of support or at other inaccessible places. These leaks are one of the largest sources of expense in the plant. Constant vigilance must be exercised to detect new leaks and if they are beyond remedy to arrange receptacles to catch as much of the solution as possible. One of the routine duties of the operator must be to collect and empty these drippings. A concrete floor has been placed under each tank to catch leaks, but it fails in its purpose because so much water gets into it in one way or another that any ammonia solution is diluted to a point where it does not pay to save it. The writer believes all this difficulty can be eliminated by electrically welding the tanks when they are first installed. It is doubted whether this would prove successful on tanks which have been long in service and whose seams are coated with silt and scale.

Gage glasses on leaching tanks are unnecessary. If used they must have all-iron fittings which are expensive and hard to get. One should guard against running up the cost of installation with such accessories, which may be convenient, but can be dispensed with.

Filters

The entire bottom of the leaching tank is covered with a filter bed adapted from cyanide practice with practically no change. One thickness of heavy duck makes a satisfactory filter and can be purchased already sewed and cut to fit the tank. To protect this cloth from mechanical wear a cover of "cocoa matting" is placed over it. Both cloth and cover are cut 6 to 10 in. larger than the bottom of the tank, and this flap is calked into a recess left between the tank wall and the wooden grid which supports the cloth. A piece of manila rope calked into the trough holds the cloth firmly in place, and as an added precaution strips of wood are nailed around the circumference on top of the filter and its cover. The grid to support the cloth can be made of fir strips 2 in. high and 1 in. wide nailed together so as to leave a 1-in. space between each two strips. They must be notched on the under side to permit free drainage of the filtrate along the bottom of the tank to the outlets. They must not be fastened with metal clips or strips, because these soon disintegrate in the leaching solution, and lodge in valve seats, pump impellers and other unfortunate places all over the system. After from 18 to 24 months' service the grid becomes soft and pulpy and must be replaced. The life of a filter can be greatly extended by always leaving 6 in. of tailings on top of it when excavating the tank. Under such circumstances filter cloths and covers ought to last 12 months. This natural filter bed must be changed every few months when it becomes saturated with slime. This bed forms a dead space in the tank that will not impart any copper to the leaching solution which occupies it; hence the first few tons of solution drawn off the tank after the first leaching period will be low in copper, and should be run into the weak solution tank to avoid diluting the main part of the rich solution.

Doors

All doors and frames are of cast steel, with finished surfaces where they meet. They can be forced shut on a gasket by means of a screw clamp. The most satisfactory cheap gasket for everyday use on 12 x 12-in. and 12 x 16-in. doors consists of several thicknesses of building paper well smeared with some sticky substance such as paint—cold-water paint is good. This gasket can be used but once. Sheet rubber packing makes a

better but much more expensive gasket that can be used several times. Asbestos sheet and woven packing is yet more expensive and no better. Cotton wicking is always kept for emergencies; improperly packed doors in the bottom of the tank cannot be readjusted after the tank is full, but their leaks can be mitigated by calking with a bit of wicking around the outside.

Piping and Pumps

Under some conditions the ammonia solution has a chemical action on iron. A hot solution containing a little copper will corrode the iron walls of a pipe to such an extent that the pipe is eaten entirely away at the threaded connection after a few months, and has to be renewed. Metallic copper is left behind, and presumably the iron goes off as a hydroxide. After more than two years of continual service the leaching tanks, however, do not show any evidence of such action; it is thought that the solution has to be in rapid motion,

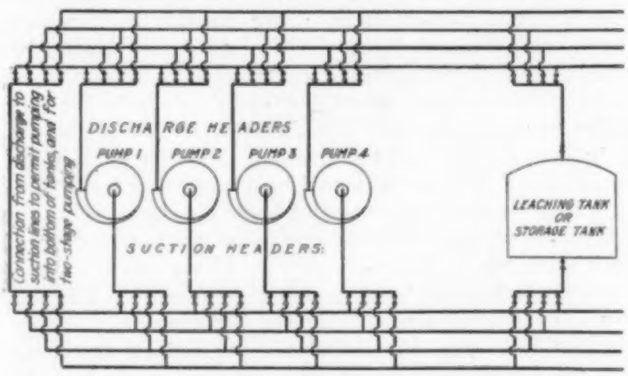


FIG. 3. PIPE AND PUMP DIAGRAM

as in flowing through a pipe, in order to promote corrosion.

It is possible to transfer all ammonia solutions needed in this process with six pumps. There are also a number of pumps required to handle cooling water for the condensers, water for use in excavating the leaching tanks, and other uses determined by local conditions. It is good practice to have not more than two sizes of pumps, make these a standard and have all pumps, both water and solution, in either one or the other of these sizes and of identical make and construction. This means that all-iron ammonia pumps will be used on ordinary water service, but the saving in the initial outlay for spare parts alone will cover the additional cost of the pump. When it comes to piping, a great saving in the money tied up in the warehouse can be effected by installing not more than two different sizes of pipe. For all ordinary work 2-in. piping is ample, both for suction and discharge pipes. By arranging the pumps on interconnected headers, as shown in Fig. 3, it is possible at times to allow two suction lines to discharge into the same pump so as to give ample suction-pipe capacity.

The most satisfactory small size pump which has been tried out is a centrifugal pump direct-connected to an electric motor. Such a pump with a 5-hp. motor and inclosed type impeller will deliver 125 gal. per min. against a 50-ft. head. The inclosed impeller is more efficient than the open type, but must be carefully watched to remove bits of wood and ore that lodge there and cut down the capacity of the pump and of the whole plant. In installing a pump it should be carefully gone over, because manufacturers of "all-iron" pumps obstinately insist on fitting them out with brass pet-cocks, screws, etc., which must all be taken off before using.

Small reciprocating steam pumps are troublesome affairs to pack and oil, in comparison with centrifugals, and are not very economical unless their exhaust can be utilized. There is an excess of waste heat about a leaching plant as it is, so that ordinarily no use can be found for any such exhaust steam.

Air lifts, where the compressed air comes in contact with the solution, are not favored, because a certain amount of ammonia would be carried off with the exhaust air in the form of vapor. A steam injector might prove very feasible for the purpose of charging the rich solution into the evaporators, where the heating of the solution would be a desirable feature. An all-iron injector for this purpose has been under consideration for some time. At present the evaporators are charged by a 10-hp. 4-in. centrifugal pump, which is our large standard pump.

Filtrate From Evaporators Hard to Handle

The most difficult solution to handle is the filtrate from the evaporators, or "boiled-out solution," as it is called. It is hot and contains enough dissolved copper to act strongly on the iron valves and piping. Valve wedges and stems will be put out of commission after only a few weeks' service. There is also copper oxide present which has leaked through the filter cloths and is carried along in suspension. This acts like emery dust, quickly cutting the shaft and thrust-bearing surface of a pump. The most satisfactory method of handling this material has been to apply steam pressure to the filtering tanks, so as to force the liquid through the filter cloth and out to the settling tanks.

Operating a centrifugal pump is something of a fine art at best, and with ammonia solutions new symptoms develop which a novice would fail to diagnose. For instance, in pumping strong ammonia solution, the reduction of pressure in the suction pipe causes some ammonia to vaporize and spoil the priming of the pump. By placing an ammeter on the pump motor it is possible to locate many troubles accurately; it shows whether a gland is too tight, or so loose as to let air suck into the pump (a very common trouble); it detects a plugged pipe line or a valve accidentally left closed. By suitable switch connections one ammeter on the switchboard can be connected to any pump motor at will.

There will always be some leakage about the pump glands; solution pumps should therefore be placed in concrete basins which will save this drip and allow it to drain into a sump. A very important feature about saving these drippings is to prevent them from becoming so diluted with surface water that it will not pay to save them.

It is a great help in "breaking in" new operators to paint the various solution lines with distinctive colors. In fact, if the operator-elect paints these over himself so much the better; assignment to this duty in our plant has now come to mean that a man is "on deck" for an operator's job. Solution pipes should never be buried, but should be left out in the open for easy inspection and repair. Lines carrying hot solution will have to be frequently replaced, both pipe and valves, so a lavish use of unions is good economy.

As for valves, standard all-iron "clip" gate valves are very satisfactory and are standard practice at Kennecott. They usually cannot be relied upon to seat absolutely tight after a little wear. Plug cocks may be used, but in the 2-in. size are very hard to manipulate. Special ammonia valves and fittings, such as refrigerating plants use, are absolutely unnecessary and very expensive. A permanent pipe fitter's bench fitted out with vise, cutters, taps, dies, etc., is a very essential part of the plant.

THE EVAPORATORS

The evaporator is the real heart of the plant. It has a twofold purpose: first, to remove the dissolved copper from the system at the rate it enters into solution from the ore, so as to maintain the dissolved copper in a state of equilibrium; and secondly, to remove water from the system as fast as it is introduced from the moisture in the ore and from the steam that enters the system, so as to maintain the volume of solution nearly constant at all times. From the standpoint of economy it is very important to minimize the quantity of water entering the system so as to save steam in the evaporators; in other words, it is better to evaporate a small quantity of solution, rich in copper, than a large quantity of weak solution.

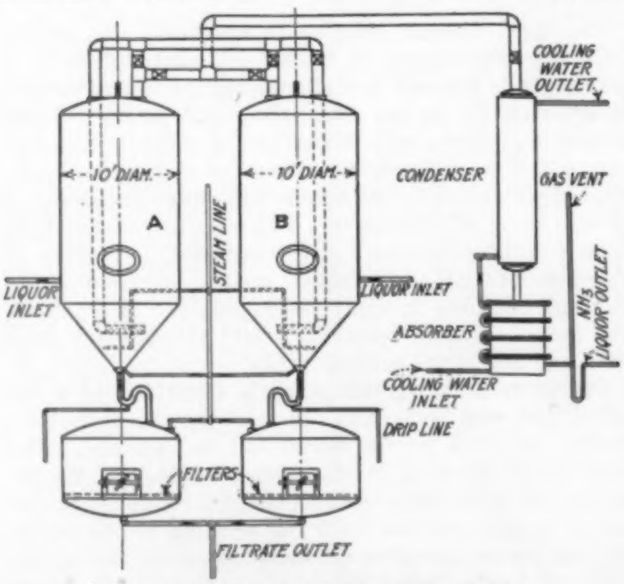


FIG. 4. DIAGRAM OF EVAPORATORS

Fig. 4 shows one of the duplicate units that have been evolved for our use after expensive large-scale experiments with various types of evaporators. While it will no doubt be further modified from time to time, this is by far the most satisfactory type put in operation up to the present.

The great difficulty in evaporator construction and operation has been the hard scale of copper oxide that tends to form over the interior surfaces both of the evaporator itself and also any steam coils or other heating surfaces. This renders the ordinary continuous distilling column with its complicated passages and trays absolutely useless after a few hours' operation. The higher the copper content the more this trouble is aggravated. However, scale will not be deposited on vertical surfaces, or on steep surfaces making an angle of 40 deg. or less with the vertical. Hence the evaporators of Fig. 4 have eliminated all this scale trouble and will run for months without cleaning. There are no heating surfaces to crust, because steam is admitted directly to the solution from a perforated pipe. It is also very essential to admit a jet of steam to the tip of the cone to keep the precipitated copper agitated—if allowed to settle it forms a dead space that would remain saturated with ammonia, and this ammonia would be lost when the precipitates are dumped into the filtering tank. Moreover, settled precipitates are liable to form a cake that will not readily pass through the discharge cock. It is sometimes necessary to start the discharge by means of a long poker worked through the vent in the top.

DETAILS OF OPERATION

At the start of operation both *A* and *B* are filled half-full of rich copper-ammonia solution. In practice this will test 5 per cent copper and 7.5 per cent ammonia. Steam is then turned into *A* only, and the valves in the vapor line set so that the resulting vapors will pass from *A* into the solution in *B*, and serve to heat *B*. The vapors from *B* are passed through the condenser, which reduces the ammonia and water to liquid form. This condensate, together with the non-condensible CO_2 gas, flows downward through the absorber or cooler, the gas bubbling through the liquid so as to scrub out all the ammonia. The liquid is then received in a storage tank and held ready for use again as a fresh leaching solution. The CO_2 escapes through another scrubber, where it is washed with water or a weak ammonia solution.

As the solutions in *A* and *B* commence to become warm the evolution of CO_2 becomes noticeable well before the boiling point is reached. No definite temperature can be set for this occurrence, because it depends on the composition of the solution, but usually the gas becomes noticeable at 130 deg. F., and very large volumes are given off before any ammonia vapor reaches the condenser. Between 160 and 170 deg. F. and under a pressure of 2 to 5 lb. gage in the evaporators, the solutions commence to boil and evolve ammonia vapor. Shortly after the ammonia starts, the evolution of CO_2 dies down and practically ceases. From this point to the end the evaporators show a bad foaming tendency, hence they are filled but half full at the start, and great caution is used in admitting the steam. A practiced operator, however, will easily control his evaporators so that only an occasional trace of copper solution will pass over into the condenser. The first ammonia vapors to go over into the condenser are, of course, very strong, but as the boiling continues they gradually become weaker, until at the end of the run they may be only 1 or 2 per cent ammonia, the rest being water. The average ammonia content of the condensate from a complete run will be about 16 per cent.

After five or six hours' boiling the ammonia content of the solution in *A* will have fallen to less than 5 per cent, and at this point copper begins to precipitate. It first comes down as a green copper carbonate, and would stay in this form unless steps were taken to prevent it. By raising the pressure in the evaporator to over 10-lb. gage, and by keeping the precipitates agitated with the jet of steam in the tip of the cone, the carbonate is changed to the black copper oxide. This latter is a more desirable shipping product, because it will contain more than 75 per cent copper, as against 60 per cent for the green carbonate. However, if the market should develop, a very good grade of copper carbonate could be produced.

Steam is kept on *A* until all but a trace of the copper has been precipitated and the ammonia content of the solution has been reduced to 0.03 per cent. This should require 10 to 12 hours. At the same time the solution in *B* will have been reduced to about 2.5 per cent ammonia, and the copper partly precipitated. Steam is now turned off *A*, the discharge cock opened, and the entire contents dumped into the filtering tank. Next a fresh charge of rich solution is pumped into *A*, steam turned on *B*, and the vapor valves reversed so that vapors from *B* pass into *A*, and from *A* into the condenser. *B* can now be boiled down to 0.03 per cent ammonia and dumped into its filter, and the procedure continued indefinitely.

While the evaporators are boiling, steam is turned into the filter tanks at about 15 lb. pressure, so as to force the "boiled-out" solution through the filter and leave the precipitated copper oxide on the cloth. The precipitate can be dried in this manner to less than 18 per cent moisture, in which condition it is sacked and shipped to the smelter. The filters consist of two layers of 8- to 10-oz. duck, protected by one cover of "hop cloth" and supported by a perforated metal screen. The cloths must be renewed about every four weeks, and the screens every four months. The filtrate should be passed through a series of settling tanks to save the small quantities of precipitate that always go through the cloth and the occasional large amount due to defective filters. The filtrate may also be passed over scrap iron, which will precipitate a small amount of cement copper from the last traces left in solution. If this is done, care must be taken not to allow the cement copper to cool while under the solution, because if it does the trace of ammonia present will redissolve it.

The discharge cocks on the evaporators are 4-in. all-iron asbestos-packed plug cocks, with easily replaceable packing. Every week the plug should be taken out, polished, well oiled, and a new packing inserted. Even with this care, at times the cocks will leak and allow rich solution to escape from the evaporators. However, such leakage may be trapped and saved as shown in Fig. 7.

The condensers are fitted with 2-in. boiler tubes of charcoal iron 12 ft. long, which have to be renewed about every eight months. At least 65 gal. per min. of cooling water must be available for each condenser, although they may not need this quantity all the time.

Plant Control

The services of one chemist are employed on routine analysis of solutions, and experimental work. Analyses of the ore are made in the regular assay office by the mine assayer.

The following simple method of testing solutions for copper and ammonia was worked out by Mr. E. B. Hunn, plant chemist: 10 cc. of solution to be tested is titrated against a standard cyanide solution until it is colorless; the amount of cyanide used indicates the per cent copper in the solution. Another 10 cc. is titrated against a standard H_2SO_4 solution, using methyl orange indicator; the acid reacts with both copper and ammonia until the solution is neutralized, at which end point it takes on a pale green color. From the quantity of acid used, and from the previously determined copper content of the solution, a specially prepared chart enables one to find the per cent of ammonia in the solution. These are the only determinations ordinarily needed to control the plant.

It is part of the operator's duties to sample every batch of solution which is pumped. He takes the samples from the discharge side of the pump through a special cock into a sample-bottle, labels it and leaves it in a rack for the chemist. There is often a wide variation in ammonia and copper content in standing solutions at different depths in the same tank. Due to this stratification it is necessary to take the sample in several equal parts uniformly spaced over the entire time of pumping. The operator also keeps a daily log sheet, on which are entered the time, quantity and disposition of every batch of solution pumped. Once daily he reads the gage glasses on every storage tank and enters this in the log sheet. Most of these storage tanks are 16 ft. in diameter by 20 ft. high, and the scale is calibrated to read in tons of 2000 lb. of solution. This unusual unit of liquid measure is very convenient as to size, and saves a great deal of work when figuring in connection with quantities of ore, which of course are expressed in tons.

It is to be noted that all these measurements, and the titrations for copper and ammonia, are really volumetric, and are accurate measures of weight only when the solution has a specific gravity of unity. This is seldom the case in practice, various solutions ranging from 1.06 to 0.97 gravity, so that for special purposes these differences must be taken into account.

Costs

To say that our leaching expense amounts to $1 per ton of ore treated is misleading. There are some very unusual conditions in Alaska; there is no standard method of keeping mining costs, and the cost of treatment is greater for rich ore than for lean ore. Therefore the following example has been worked out, using the same quantities of labor, steam and ammonia which

EXPENSE OF LEACHING 450 TONS OF CRUSHED AND DESLIMED MILL TAILINGS PER 24 HOURS

Copper (oxidized) content of ore leached.......... 0.85 per cent

Copper (oxidized) content of ore tailings.......... 0.17 per cent

Gross extraction is 13.6 lb. copper per ton leached. Of this about 1 per cent, or 0.1 lb., must be deducted as dissolved copper lost in the leaching process, leaving 13.5 lb. per ton to ship to the smelter. This is shipped in the form of copper oxide containing 75 per cent copper and 18 per cent of total weight as moisture (per cent copper figured on dry weight). Smelter deductions will amount to 0.2 lb., so that the net copper sold will come to 13.3 lb. per ton leached, or 5985 lb. per day.

Leaching Expense for		Total Per Day	Per Ton	Per Lb. Cu Sold
Direct Labor:				
1 Foreman at $6.00	$6.00			
1 Chemist..... 5.00	5.00			
3 Shift bosses 4.50	13.50			
3 Operators 4.00	12.00			
9 Laborers 3.50	31.50			
1 Repair man 4.50	4.50			
Total	$72.50	$72.50	$0.161	$0.0121
Power and Lights:				
630 kw. at 2.5c. per kw (1.4 kw. per ton)		15.75	.035	.0026
Ammonia:				
0.25 lb. per ton loss in leaching	$0.25			
0.02 lb. per lb. Cu loss in evaporators. 13.5 × 0.02	.26			
Total loss per ton	$0.51			
Cost, at $0.50 per lb. NH_3		114.75	.255	.0192
Steam:				
94 lb. per ton for steam wash	.94			
16 lb. per lb. Cu for evaporation 13.5 × 16	216			
Total steam per ton	310			
Cost at $0.001 per lb.		139.50	.310	.0234
Maintenance and Repairs:				
Includes cost of all maintenance of machinery and buildings, both materials and extra labor necessary		25.00	.055	.0042
Operating Supplies:				
Sacks, oil and waste, packing, etc.		15.00	.033	.0025
Total leaching expense		$382.50	$0.849	$0.0640

have been found necessary at Kennecott, but changing the rates somewhat to conform with more usual conditions.

It should be especially noted that the above is the leaching expense only. No charges are included for overhead, mining and crushing the ore, tailings disposal, freight to smelter and smelting charges, or selling expense. Little if any profit could be shown in leaching such a lean ore, if all these charges had to be borne by the leaching plant. But in the case of treating tailings from a primary concentrator, as at Kennecott, it is perfectly proper to charge the mining, crushing and tailings disposal to the main plant, which would have to bear this expense if the tailings were not treated, and under these circumstances it is possible to show a profit with very lean ores. In this connection it should be noted that ammonia and steam expense, which are the two largest items, vary not only in proportion to the tons of ore but also in proportion to the copper extracted. Hence it is not so expensive to treat lean ores. Power, maintenance and supplies will vary as the tonnage, while labor is constant and not affected by either tonnage or production.

As for first cost, construction expenses vary a great deal with local conditions. In the light of past experience, and under normal conditions, it is thought that $300 per ton of ore-treating capacity per day would be a reasonable estimate of the first cost of a small plant as herein described. One large item that must not be overlooked is the initial supply of ammonia. Some 275,000 lb. of 26 deg. aqua ammonia or equivalent must be accumulated, and this may easily cost more than $30,000. Unless skill and foresight are used in manipulating the plant operations, "peak" demands for ammonia will at times call for a much greater supply. The foreman must aim to keep all his ammonia at work all the time, for idle solution represents not only an idle investment in itself, but calls for additional storage tanks, and is a positive loss from leaks and evaporation.

Canaan, Conn.

Semi-Annual Meeting of American Institute of Chemical Engineers

Dr. John C. Olsen, secretary, has announced that the summer meeting of the American Institute of Chemical Engineers will be held at Boston, June 18 to 21, inclusive. A symposium on Electric Furnaces is being prepared. Further details regarding the program will be given in an early issue.

New Jersey Chemical Society

Colonel F. M. Dorsey of Cleveland, Ohio, Chief of the Development Division of the Chemical Warfare Service, will give an illustrated lecture before the New Jersey Chemical Society on Monday evening, April 7. The lecture is entitled "Activities of the Development Division of the Chemical Warfare Service," and will deal particularly with the development of manufacturing methods for mustard gas and for dorsite, or activated charcoal, with which Colonel Dorsey has had considerable to do.

Another item of present interest is a general discussion on "Permanent Results From Wartime Necessities" led by Professor R. G. Wright, of Rutgers College.

Dinner will be served at Stetter's Restaurant, Newark, at 6:30.

Imports and Exports

The Bureau of Foreign and Domestic Commerce of the Department of Commerce gives out the following statistics of imports and exports for January, 1919:

IMPORTS AND EXPORTS OF COPPER, BY CLASSES

Imports

	Gross Tons	Copper Content, Lb.	Value
Ore	11,697	2,919,767	$643,777
Concentrates	9,379	2,505,000	647,600
Matte and regulus	4,341	4,501,623	894,623
Unrefined, etc., in bars	......	5,065,683	1,256,250
Refined, in bars, plates, etc	......	4,019,469	983,753
Old, etc., for remanufacture	......	1,676,525	258,446
Composition metal	......	3,141	565
Copper manufactures	......	....	....

Exports

	Gross Tons	Copper Content, Lb.	Value
Ore	1,530	318,946	$65,303
Concentrates	......	....	....
Unrefined, etc., in bars	......	....	....
Refined, in bars	......	72,757,340	18,381,796
Composition metal	......	8,882	3,238
Old and scrap	......	25,040	4,518
Pipes and tubes	......	356,340	137,861
Plates and sheets	......	3,130,974	884,669
Wire, except insulated	......	3,289,411	963,793
All other manufactures	......	....	526,138

IMPORTS AND EXPORTS OF GLYCERINE, BY COUNTRIES

	Lb.	Value
Imports (total)	15,807	$4,741

Exports

Country	Lb.	Value
Azores and Madeira Is.	163	$30
Norway	4,000	4,000
England	100	35
Bermuda	25	18
British Honduras	14	9
Canada	72,474	40,157
Costa Rica	60	46
Guatemala	300	142
Honduras	150	118
Nicaragua	60	29
Panama	3,876	1,608
Salvador	151	111
Mexico	4,566	2,895
Newfoundland and Labrador	16	9
Barbados	100	58
Trinidad and Tobago	70	60
Cuba	13,690	7,968
Virgin Islands	100	65
Dominican Republic	415	177
Argentina	2,240	1,400
Bolivia	900	720
Brazil	215	150
Chile	1,378	993
Colombia	1,349	926
Ecuador	3,552	1,848
British Guiana	100	78
Dutch Guiana	5	4
Paraguay	50	43
Peru	8,189	3,520
Uruguay	110	94
Venezuela	667	378
China	3,412	2,208
British India	50	44
Dutch East Indies	4,586	3,436
Hongkong	2,050	1,130
Japan	652,522	386,377
French Oceania	30	12
Philippine Islands	6,041	2,794
Belgian Kongo	88	53
British South Africa	18,049	4,912
Total	805,913	468,655

U. S. EXPORTS OF CAUSTIC SODA AND SODA ASH, BY COUNTRIES

Country	Caustic Soda		Soda Ash	
	Lb.	Value	Lb.	Value
Denmark	112,000	$4,458	1,240,866	$42,266
Italy	1,626,048	129,620	....	....
Norway	60,075	2,523	141,275	6,016
Portugal	350	198	....	....
Sweden	22,400	800	....	....
British Honduras	200	14	....	....
Canada	1,110,649	46,423	3,785,959	97,551
Costa Rica	48,145	2,895	16,500	563
Guatemala	29,607	1,480	....	....
Honduras	27,270	1,511	114,670	4,836
Nicaragua	24,330	1,603	16,400	661
Panama	43,584	2,081	7,000	214
Salvador	28,580	1,759	556	24
Mexico	2,626,192	145,925	357,381	11,053
Barbados	26,400	1,806	....	....
Jamaica	1,218	79	....	....
Trinidad	1,350	82	....	....
Other British West Indies	350	14	....	....
Cuba	629,134	26,398	1,011,350	12,403
Virgin Islands	1,800	182	....	....
French West Indies	6,650	455	....	....
Haiti	100	7	....	....
Dominican Republic	68,822	3,567	6,000	220
Argentina	2,599,953	119,581	248,585	10,733
Bolivia	136,620	7,126	....	....
Brasil	1,740,162	112,976	1,836,587	66,256
Chile	156,500	9,826	110,455	3,498
Colombia	582,041	32,507	165,750	8,910
British Guiana	....	....	310	12
Dutch Guiana	7,600	380	....	....
Paraguay	56,025	1,597	64,812	1,202
Peru	282,595	15,321	112,320	5,699
Uruguay	189,367	8,124	97,903	2,443
Venezuela	155,585	7,150	....	....
China	469,766	20,941	908,599	38,092
British India	221,110	11,000	....	....
Straits Settlements	40,000	1,600	17,920	761
Dutch East Indies	11,400	684	64,500	3,225
Hongkong	317,135	17,742	19,000	855
Japan	1,623,548	83,063	3,554,640	125,181
Australia	1,360,284	89,175	974,318	47,951
New Zealand	118,590	9,229	22,400	800
Philippine Islands	816,375	31,847	138,000	7,539
British South Africa	22,275	1,002	....	....
Total	17,402,185	954,751	15,034,056	498,964

Future of Industrial Organic Chemistry

Brief Review of the Several Groups of Industries Depending on Organic Chemical Development, Such as Food, Clothing, Fuel, Drugs and Arts—The One-Plane Basis of Studying Organic Reactions Should Be Abandoned for the Spatial Energy Theory Advanced by Michael

BY HAROLD HIBBERT

WITH regard to the late war it may be accepted as a truism that the peace and safety of the whole world rested on a far-reaching knowledge of the underlying principles of scientific and technical chemistry.

A review of our chemical knowledge, both scientific and applied, shows that prior to 1914 the chemistry of the aromatic compounds had been moderately well developed in this country, while that of the aliphatic had been more or less neglected. The reason for this is probably traceable to the influence of the German school of thought. Inasmuch as there existed in Germany large supplies of the raw materials necessary for the production of aromatic derivatives such as toluene, benzene and naphthalene, from which dyestuffs and pharmaceutical products are manufactured, it was natural, in view of the world markets obtainable for these finished materials, that this field should have been developed much more intensively than that of the aliphatic compounds such as the products from wood distillation, grain alcohol, fats, oils, gasoline, etc., all of which were imported products. Not only this, but the dyestuff industry forms, more than any other, the pivot around which so many different manufactures revolve.

In addition, it has always been tacitly assumed that the aliphatic compounds, especially those of saturated character such as the hydrocarbons (gasoline, etc.), are relatively inert materials, and consequently much less "plastic" than the aromatic derivatives; in other words, less capable of being transformed commercially into other products of industrial importance.

Four Main Divisions of War Requirements for Chemists

If we review the war requirements, we find that they may be divided, in so far as the chemist is concerned, into four main divisions:

1. Foods and food products
2. Medical and pharmaceutical supplies
3. Explosives and their intermediate derivatives
4. Poison gases.

A consideration of these shows that the aliphatic chemical compounds have played a rôle equal, if not superior, to the aromatic derivatives. In consequence, university professors, graduate students and technical chemists have, in many cases for the first time, been able to acquire a deep and far-reaching knowledge of the properties of aliphatic substances. If during the last forty years we have specialized on the technical application of the aromatic bodies, it is because it "paid to imitate Germany," but the prediction may now be made with safety that the industrial progress of the next half century will be intimately associated with the development of the chemistry of the aliphatic products.

A consideration of the subject will show that our necessities, comforts and luxuries are all closely related to products of the former class. This is clearly proved among other things from a consideration of the immense capital tied up in the manufacture of products of an aliphatic character. Thus with regard to foodstuffs, we have the vast industry of the edible oils, palm, cocoanut, cottonseed, soya bean, peanut, fish oil, etc.; and closely allied to this, the cyanamide fertilizer industry.

For our heat and light, we require gasoline and candles. Our clothing is derived from cellulose, either in the form of cotton or as artificial silk. Of our medical supplies, it is only necessary to mention such materials as glycerine, methyl and ethyl alcohols, formaldehyde, paraldehyde, chloral, etc. In the matter of luxuries, the moving-picture industry depends on a supply of cellulose derivatives either in the form of nitrate or acetate, while in the late war the most deadly of the various toxic gases employed was the so-called "mustard gas," which in addition to the products already mentioned is also a representative of the aliphatic series.

Value of Aliphatic Materials

Some idea of the value of these materials may be obtained from the following figures:

Value of cotton crop (1918)[1]	$1,616,207,000
Value of natural gas (1917)[2]	142,089,334
Value of products of wood distillation (1914)[3]	10,236,332
Domestic production of vegetable oils (1917) lb.	2,159,335,000
Domestic production of animal and fish oils (1917)[1] lb.	1,636,451,000
Domestic production of butter (1917) lb.	1,369,500,000
Total, lb.	5,165,286,000

The imports of fats and oils in 1917 amounted to 636,288,306 lb., while 584,254,000 lb. were exported. If we compare these with a total value of $40,044,427[4] for the entire output of crude coal tar products (tar, light oils and naphthalene) for 1917 the difference is striking.

The edible oil and fat industry is one of the first magnitude, and yet it will be admitted that the scientific principles regarding the hydrogenation of vegetable oils were first developed scientifically in France, then technically in Russia, Germany and England, and last of all in this country. As in the case of many of the most important technical developments, the work may be traced in its original conception to the scientific researches of Frenchmen, in this case Messrs. Sabatier and Senderens.

[1]Figures supplied through kindness of Department of Commerce.
[2]Figures supplied through kindness of Department of the Interior.
[3]Figures supplied through kindness of Department of Agriculture.
[4]Figures taken from Bulletin No. 769, Department of Agriculture.

While it may be allowed that this country has carefully followed the European patent situation, and endeavored to take advantage of it and improve on the same, yet in so far as the main general scientific aspects are concerned, it has shown relatively little scientific originality. Thus while celluloid is distinctly an American invention, the underlying scientific facts connected with the manufacture of stable nitrocellulose were largely developed through European studies. Without a knowledge of these fundamental properties it would not have been possible to proceed to the discovery that celluloid can be manufactured by compounding cellulose nitrate with camphor. The same holds true with regard to cellulose acetate and xanthogenate, the latter employed in the manufacture of artificial silk.

Universities Responsible for Neglect

There can scarcely be any doubt that the universities are in large measure responsible for the neglect of the study and technical application of the aliphatic derivatives. This neglect would seem to be to a large extent traceable to the faulty method of instruction, and the inability to make a student visualize the products with which he is called upon to deal. In other words, organic chemistry has been made a subject of "blackboard one-plane valency impressions" rather than a consideration of the energy and spatial relations of the constituent atoms in the molecule, and in this latter connection, it is difficult to understand why the work and theories of Michael have not been given much more prominence. The importance of training the student to visualize the spatial relations of the atoms in all organic compounds cannot be overemphasized. Instead of the customary procedure of showing the model of the carbon atom in the one or two isolated cases connected with stereoisomeric and optical derivatives, or in the case of the benzene ring, it would seem desirable to have available, at every lecture on organic chemistry, models which could be constructed so that the nature of the spatial arrangements would be at once apparent to the students, and instead of the customary one-plane representation, it would be possible for them to visualize at a glance the effect of the proximity of the atoms in the molecule and of the effect of the different forms of energy associated with the same, considered from the point of view of their spatial relations.

Thus all of the important properties such as substitution, ring formation, oxidation, reduction, etc., could be taught from this standpoint, and the value of an atom in the 1, 2, 3, 4, 5, etc., position relative to another atom attached to carbon, clearly defined and so thoroughly fixed in the mind of the student that, when called upon to advise on some process in connection with the manufacture of a synthetic product, he would never be at a loss to predict, at least in general terms, the nature of the material to be synthesized, and to indicate some procedure looking toward its successful manufacture.

While not wishing to detract from the interesting researches of Fry and Jones, or from the interesting discussions of Falk and Nelson, as well as of G. N. Lewis, it would seem, in so far as the technical side of organic chemical problems is concerned, that for the present the theories of Michael, though in some respects vague and indefinite, largely on account of the impossibility of providing all the quantitative data, yet at the same time do provide a working hypothesis which undoubtedly assists the research chemist to a remarkable extent in predicting the nature and course of chemical reactions and of the properties of unknown chemical individuals.

If a student learned to grasp thoroughly the fundamental principles underlying the relative energy values of the atoms in the molecule, and to obtain a more profound and comprehensive knowledge of the facts of catalytic phenomena bearing on organic chemistry, he would be placed to-day in a far more advantageous position for solving the various technical problems arising in connection with the development of outlets for the commercial and industrial utilization of naturally occurring products found in this country.

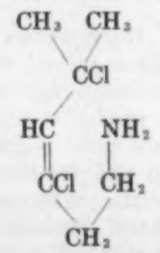
Pitfalls of the Young Chemist

The young research chemist in the industry is too apt to attempt to transfer his college knowledge of the "type properties" of any chemical compound to the derivative to be synthesized instead of realizing that the problem to be solved is in general one in which, for some reason or another, the "type property" has either ceased to exist, or has been considerably modified through the influence of certain groupings or atoms in the molecule. Thus he fails to realize that a reaction of any group such as carboxyl or hydroxyl, instead of representing a definite fixed property *per se*, is in fact rather a summation of properties representing a combination of the play of the various energies and affinities of the entire reacting atoms comprising the molecule; in other words, the group does not exist alone. It is this understanding and appreciation of the varied influence of each atom in the molecule on each other atom which enables the trained chemist to predict chemical phenomena and properties, and as the ability to predict is a true measure of the ability to invent, and invention and progress naturally move hand in hand, the importance of such knowledge is readily apparent.

Much has been heard of the various psychological tests employed in the Army, and it would seem that equally satisfactory tests applicable to college men desiring research positions should be devisable. One suggestion in this connection is that at the conclusion of the usual course of organic chemistry a series of seminar exercises should be given in which, by the use of models, the students should be called upon to give indications of their ability to predict the nature and properties of different chemical compounds. Thus, for example, with a compound of the formula

$$\left.\begin{matrix}CH_3\\CH_3\end{matrix}\right>CCl - CH = CCl - CH_2 - CH_2 - NH_2$$

which preferably should be written



the student could be asked to set up the carbon models, and then, with these in full view, he asked to predict the effect of various reagents on the various atoms in the molecule; in this case, the tendency toward ring formation, the action of alkalis, effect of oxidizing

agents, removal of halogens, properties of the different hydrogen atoms, etc. A satisfactory answer to such questions would, from the technical research standpoint, provide evidence much more valuable of the man's probable research ability than reams of paper dealing with his knowledge of the dozen different ways for making, let us say, ethane or other derivatives.

The fact that acetaldol can be made by the condensation of acetaldehyde with alkalis, etc., and the various conditions which must be observed in carrying out such a reaction are of less importance than the ability to predict, for example, just in what manner, say, acetaldehyde would condense when mixed with some other aldehyde, for instance, isobutyric aldehyde.

The same is also true of the ability to foresee, for example, the point at which substitution will occur when a hydrocarbon, for instance, propane, hexane, etc., is subjected to the action of bromine, etc., or again where it will occur in the case of acids and acid chlorides.

These problems and many others of vital interest and importance are to be found discussed at length in the published work of Arthur Michael.[8]

The Training of the Professor

So much for the training of the chemist. With regard to the training of the professor, it would seem that he also stands in need of overhauling. In the first place he has been, from time immemorial, both badly underpaid and overworked, and both of these conditions call for urgent and vigorous action. No professor or instructor can undertake research work unless he is

1. Competent to undertake the same
2. Has adequate facilities in the way of post-graduate men and equipment
3. Has the necessary time to devote to it
4. Is adequately recompensed so that he can be free to devote himself to the scientific side of the subject without the necessity of burdening himself with onerous and uncongenial outside employment.

Granting this, there still remains the fact that the average university and college professor has hitherto not been in touch with the problems of the industrial world. He has, in fact, in many cases rather scorned any association with such, and naturally the industry has resented this and returned the feeling with interest. If the war has shown one thing, it is this, that the future generation of research chemists and chemical engineers will expect from their professors something more than a general knowledge of the theory of the subject, and will at least expect that they shall be conversant with the better known technical applications. As for the detailed knowledge, presumably this will be left to the director of the department of industrial chemistry, between whom and the professor of pure chemistry there should naturally exist the closest kind of personal friendship and scientific co-operation.

Universities to Teach Industrial Chemistry

Various universities, including Harvard, have now made a start in this direction by establishing departments of industrial chemistry, and it is to be expected that other universities such as Yale, Princeton, etc., will follow her lead. Unless this is done we shall undoubtedly fall behind other countries, as witness the marked progress being made along these lines in England and the subsidizing of English university professors by manufacturers of explosives and other chemicals with a view to utilizing the services of their highly trained intellects in the solution of different technical problems.

Various corporations in this country have already allocated considerable sums of money for similar purposes and it is now for the universities to decide as to how far they can, and will, co-operate with them in this. Instead of a series of Mellon Institutes dotted over the country, the more logical development would seem to lie in the creation of strong departments of industrial chemistry at the leading universities.

That there need be no lack of subjects requiring investigation is especially evident when we consider the natural resources of this country, and how closely their development is identified with a thorough knowledge of the chemistry, in particular, of the aliphatic compounds.

In this connection it may be of interest to take up the subjects indicated previously, namely:

1. Food products
2. Clothing
3. Fuel for light and heat
4. Medical supplies
5. Luxuries and arts,

and to glance briefly at the progress and developments which have been made regarding these during the last few years, and at the same time to indicate the general trend of future industrial development.

Slogan Should Be "Tolerate No Waste"

In the first place, in view of the recent prodigal waste of the world's resources, it is now necessary to "think internationally" as well as nationally. After all, the world's resources are not unlimited, so the slogan of the chemist from now on should be, "We shall tolerate no waste." As an illustration of this, if it can be shown that our entire supply of ammonia can be obtained from the coke oven gases, then it would seem logical to enact the necessary legislation to enforce the introduction of the recovery system to the entire coke industry, while other processes, such as the manufacture of cyanamide, which encroach on our limited available supply of coal and power should, if necessary, be excluded from the manufacture of such material.

In the same way if we can produce the country's requirements of alcohol and acetic acid economically from such materials as waste wood, which it must be admitted seems rather unlikely, then from the "world conservation standpoint" these processes should logically receive more attention than when prepared by other methods involving the use of raw materials, limited in extent and capable of being adapted more effectively and efficiently to other branches of the arts. In this connection it is also true that the manufacture of ethyl alcohol from waste pulp sulphite liquors, if possible from a commercial standpoint, is also true conservation when considered from the point of view of the utilization of foodstuffs such as corn, etc., for the same purpose.

What can the technical chemist do to assist in bringing down the high cost of living? How can the universities, colleges and scientists assist him? A brief attempt will be made to answer these questions. Concerning the list previously quoted, namely, food products, clothing, light and heat, medical supplies and luxuries, an examination will show that they are ar-

[8]See, among others: *Journ.* pr. chem. 60, p. 286-409 (1899); 68, p. 487-520 (1903). Berichte 34, 626; 4028 (1901); 39, 2138 (1906). *Journal* Amer. Chem. Soc. 32, 991 (1910); 40, 1674 (1918); 41, 393 (1919).

ranged in approximately the order of their importance with regard to the development and protection of the individual.

Food Products

For the first time in their lives millions of people have been forced to learn, during the last four years, something regarding the nature of food and food products. As is well known, the bodily requirements comprise three main divisions, namely, fats, carbohydrates and protein, a shortage of any one of which proves disastrous.

With regard to fats, these are aliphatic compounds, esters of glycerine and fatty acids, and owing to their utilization along lines other than for food, a very pronounced world shortage soon occurred in this field after the outbreak of the war. As is well known, fats are utilized for the manufacture of glycerine and fatty acids, the latter being converted into soap and various other useful chemical products, while the glycerine finds its main outlet in the manufacture of explosives, cordite, dynamite, etc.

An increase in the available supply of edible oils thus became imperative, and the production of cocoanut, peanut, palm, soya bean and other vegetable oils, together with animal fats, was stimulated to a very marked extent, and yet in spite of this the shortage abroad remained very acute. All of these oils represent aliphatic derivatives, regarding which much research work is necessary and from which, in turn, marked technical advances may be expected. Thus soya bean oil is comparatively a new product and is produced now in such large quantities that additional outlets for the material are desired. In 1918 we imported from China and Japan 335,983,492 lb., having a value of $35,454,639.

The properties, chemical, physical, etc., of peanut oil would seem to repay investigation, and the general question of prevention of rancidity in oils, especially in the case of cocoanut and palm oils, is a subject calling for the attention of the chemist. A good cheap commercial method has been developed for the deodorizing of fish oil so that the low grades, which on account of their high fatty acid content cannot be used for purposes of hydrogenation, can now be employed for the manufacture of glycerine and soap.[6] This question of the hydrogenation of fatty acids is a field offering considerable scope for the research chemist, as is also the problem of the catalytic reduction of unsaturated aldehydes and ketones whereby unsaturated alcohols may be obtained.

The oils extracted from peach kernels and other waste raw materials have also been shown to provide useful substitutes for olive oil as salad dressings, etc., so that a more extensive use for these materials may be predicted.

Carbohydrates

There also developed during the war period a considerable shortage in the supply of sugar, due in part to the inability to transfer supplies from one part of the world to another, notably from Java and other points. In consequence of this, the saccharine industry was developed both here and abroad, and some idea of the value of it may be gained from the fact that at one time in England this material sold for about $80 per pound, and it became customary for individuals to carry around small saccharine pills for the purpose of sweetening their beverages. In view of the fact, however, that saccharine is not a foodstuff, it is not likely that the manufacture of this material will be pushed to a considerable extent after the war except in the case of a few industries such as the mineral water trade, and up to the present no other substitutes have been developed and in fact they do not seem desirable. There would seem, on the other hand, to be a good opening for the development of special carbohydrate material capable of being assimilated by people suffering from diabetes.

Protein

It is probable that in the domain of the protein foodstuffs most progress is possible. The extensive researches carried out, for instance, at Yale might well be utilized for the purpose of testing out the relative value of a pronounced protein diet in comparison with one entirely vegetarian. It would be of considerable interest to divide, say, a given class into two such squads, and then to have a full report at the end of a nine-months' period as to the mental and physical condition and development of the individuals in each series.

It does seem surprising that in view of the well-known facts regarding the protein content of peas, beans, lentils, cheese, etc., there should still exist doubt in the minds of college men, chemists and others that such materials are not adequate to provide the full protein requirements. When men of such eminence in the inventive world as Dr. Leo Baekeland and others testify that their best work was done on a strictly vegetarian diet, it provides considerable solid ground for the assumption that such conduct would also be of advantage in other cases.

In this connection a few facts concerning the soya bean industry may be of interest.[7] The bean itself is grown principally in China and Japan, and the development of the oil industry has been most marked within the last twelve years. In fact, had it not been for this commodity the probabilities are that many of the soap factories would have had to suspend operations during the last two or three years. It is claimed that this country could use some 600,000 tons of soya bean oil annually, corresponding to 6,000,000 tons of soya beans. In 1918 the total imports from Manchuria were approximately 1,000,000 tons of beans, equivalent to 100,000 tons of oil. There were imported into this country in 1917 approximately 132,000 tons of oil, while the domestic production amounted to 21,000 tons.

Soya bean oil resembles linseed oil to some extent, that is, it is a drying oil and has been used largely in the manufacture of paints, linoleums and similar products. On the other hand, it is a valuable constituent of salad oils and butter substitutes and in China forms the staple food oil of large classes of the people.

Dietetic Value of the Soya Bean

Due to the fact that with ordinary methods of cooking soya beans remain rather unpalatable, their use, as such, has not been practiced to a great extent, but the

[6] It is stated that in consequence of the inability of trawlers to operate in the North Sea and other portions adjacent to the British Isles, the fish have multiplied very rapidly, so that it is expected the fishing industry will be very active during the next few years.

[7] The data are compiled from an interesting article, "The Romance of the Soya Bean," by L. S. Palen, published in the January (1919) number of *Asia*, the journal of the American Asiatic Association. The U. S. Department of Agriculture Bulletin No. 439, "The Soya Bean," by Piper and Morse; and No. 769, "The Production and Conservation of Fats and Oils in the United States," by Bailey, also contain much interesting and valuable information.

various sauces, curds, cheeses, etc., made from it have been shown to possess such marked dietetic value that there is likely to be a rapid increase in the future consumption of these products which would tend to lower the high cost of living. Analysis shows the presence of:

	Per Cent
Proteins	30 to 46
Oil	12 to 24
Carbohydrates	24 to 28

According to Osborne and Randall,[8] "The proteins of the soya bean, unlike those of other leguminous seeds thus far investigated, are adequate for promoting normal growth. . . . So far as we are aware the soya bean is the only seed hitherto investigated, with the possible exception of flax and millet, which contains both the water-soluble and the fat-soluble unidentified dietary essentials or vitamines."

However, it is not possible to enter into a lengthy discussion of the subject except to point out that the valuable results obtained in dietetic studies at Yale and other universities should be made more readily available and that at least one or two lectures on this subject should be devoted to the same in any college course on organic chemistry.

Cheap Fertilizer a Necessity

With regard to the whole question of food supply, it is necessary that cheap fertilizer should be provided, and the vigorous and active research being carried out with regard to the recovery of potash from blast furnaces and the cement industry, together with the various new methods for the fixation of atmospheric nitrogen, would seem to warrant the hope that considerable success may be expected from the experimental and technical researches at present in progress.

At present the Haber process would seem to be the cheapest method of nitrogen fixation, but it is rational to assume that the maximum efficiency with regard to the arc process has not been reached, and that valuable improvements and developments may be expected along these lines. Furthermore the difficulties incidental to operating the Haber process at lower pressures are, as yet, far from being solved.

With regard to various by-products of the food industry, some outlet, for example, should be found for cottonseed hulls and similar materials. Preliminary experiments carried out by the writer appear to indicate that when compounded with nitrocellulose cork substitutes may be made, possibly applicable to manufacture of cork stoppers, lifebelts, etc., and this is only one of many uses to which this material might be applied.

Of other points of interest connected with the food industry, there is the question of obtaining suitable oils for use in the manufacture of tin plate and the "quenching of steel." Instead of the edible palm oil other cheaper material such as cottonseed, pine oil, etc., are apparently capable of substitution.[9] Finally, with regard to the extraction of oil from the oil cake, it is recognized that the best solvent for this purpose is trichloroethylene. This is obtained from acetylene and chlorine and is not manufactured in this country at the present time, although its synthesis is not a difficult matter to carry out commercially and it is to be hoped that domestic manufacture of the material will be undertaken.

With regard to the second item listed above, namely, clothing, we find on investigation that in addition to the use of cotton as such, the manufacture of artificial silk has been developed to a remarkable extent in this country in recent times. Furthermore, it was very evident during the last two years that the country's entire available supply of knowledge regarding the scientific character and fundamental properties of certain cellulose derivatives such as the xanthogenate, and particularly the acetate, was decidedly limited in extent. It is a startling fact that while the value of cotton and cotton products such as nitrocellulose, artificial silk, etc., produced in this country is far greater than that of the rest of the world combined, yet so far as a hasty search of the literature shows there has not been a single outstanding scientific paper published in this country on the constitution of cellulose.

We have allowed the European countries to develop the scientific data on these subjects, and then made a feeble, belated attempt to obtain control of the technical applications either by purchase or otherwise. It is regrettable that in the case of the one or two large companies which have carried out scientific work in this field they should have felt under no compulsion to communicate the broad scientific results to the general body of chemists, but prefer instead to surround the matter with a complete veil of secrecy. It is not in this way that the progress of any industry can be assured, and fortunately as a result of the war, this would now seem to be much better recognized.

Fuel for Heat and Light

When we consider the bearing of aliphatic chemistry on the question of heat and light, we find this country is by far the largest producer of petroleum and gasoline products, and not only this, but it is also the largest producer of benzol, of which advantage is now being taken in connection with gasoline mixtures for use in motor cars. There would also seem to be a valuable field in the development of materials of low nitration for admixture with kerosene for use as a motor fuel. Furthermore, it is a pity that there should still be any waste of natural gas, and this material would seem to warrant the close attention of chemists and technologists from both the scientific and industrial standpoint. The action of halogens, condensing agents, contact reactions with unsaturated derivatives, etc., are all interesting fields.

The cracking of petroleum has been developed to a remarkable extent, but it would seem that there is still room for processes involving the use of other contact materials which would enable this operation to be carried out at both a lower temperature and pressure. Possibly additional research would show the advantage of metallic chlorides other than aluminium. The reactions of hydrocarbons with sulphur chlorides would also repay investigation, and the interesting experiments recently carried out with nitrosyl chloride[10] possess much interest both for the scientist and for the technical chemist.

Prior to the war, this country was almost entirely dependent on Germany for its pharmaceutical supplies. In tracing the reason for this, one fact is quite evident, namely, the close co-operation which existed there

[8] *Journal of Biological Chemistry*, December, 1917.

[9] See Department of Agriculture Bulletin No. 769, page 23, "The Production and Conservation of Fats and Oils in the United States" (1919). This is a very valuable monograph, containing, as it does, the latest available information on the subject of edible oils.

[10] *Journal* Amer. Chem. Soc., Vol. 41, p. 368 (1919).

between the universities and various pharmacological institutes on the one hand, and the industry on the other. Such well-known remedies as antipyrine, veronal, etc., were developed in university and not in technical laboratories. We still find it necessary to consult German text books and monographs for much of our information, and it now appears that the compilation and publication of such treatises on highly specialized subjects were carried out in many cases at public expense.

Is it asking too much that this Government should co-operate both actively and financially in the founding and support of a national pharmacological institute such as proposed by Dr. Charles Herty, and at the same time show its willingness to undertake the financing of the publication of scientific memoirs not warranted commercially through the usual channels?

Inviting Field for Organic Research Chemist

The scientific development of the relation of constitution to pharmacological action is one of the most inviting fields for the organic research chemist at this moment, and it is highly desirable that there should be a much closer co-operation between the biologist on the one hand, and the organic chemist on the other. It would be a grave mistake, for instance, not to take advantage of the wonderful spirit of co-operation in this field, developed as a result of their combined activities in the domain to toxic war gases. It is, for instance, inconceivable that the salicylates should represent the only type of compound best adapted to the use to which they are put, and it would seem extremely probable that active research would develop the use of better and more suitable products.

If for instance just one-half of the scientific work expended on the preparation and investigation of toxic war gases during the last two years were devoted to investigations looking to a remedy for tuberculosis, it is reasonably safe to assume that some cure would be found. In this connection it is necessary to recall the wonderful advances that have been made in the domain of biological chemistry, and referred to by Francis H. Carr in a recent lecture on "The Synthetic Organic Chemical Industry."[11]

Cure for Consumption Possible

For example, thyroxin, the principle contained in the thyroid gland, which regulates the rate of body metabolism, is now stated to be an oxyindole derivative of iodocyclohexane, and is so active that 0.3 mg. raises the body metabolism 1 per cent. The fact that thyroxin contains iodine is of considerable interest, since, as shown by the writer[12] and others,[13] a small trace of this element is sufficient to bring about the condensation of hydroxy, amino and imino derivatives. From the recent publication of Van Os[14] it would appear that the iodine present in thyroid preparations does not exert a marked influence, but in view of its remarkable activity as a condensing agent these results should not be regarded as final and conclusive. This is all the more necessary in view of the fact that in the case of tubercular patients the iodine content of the thyroid gland apparently varies appreciably from the normal, so that if some such connection could be traced, it might possibly provide a welcome guiding light as to a possible synthesis of a derivative capable of application to the cure of this terrible scourge.

When we consider broadly the nature of the products on which we depend for our enjoyment, we are again brought face to face with the aliphatic derivatives. The amusement of a large portion of the population at the present time is derived from moving-picture houses, and as is well known the films are made from cellulose nitrate or acetate. Our paper drinking cups and food containers are coated either with paraffine or nitro-cellulose and the casing of the sausage we eat is also probably a modified cellulose derivative.

No matter to what domain of the fundamental requirements of human activity, physical or social, we turn, it is evident that we are brought face to face with the properties and industrial applications of the aliphatic chemical compounds. Not only is it the duty of the chemist to develop the scientific and commercial application of such, but also to foresee and protect the individual from the harmful effects of abnormal natural and artificial conditions. Thus at the present time we are faced with national prohibition, and as this will render idle an immense amount of equipment, it is to this extent destructive of industry.

Problem of the Chemist

The problem of the chemist is, therefore, to provide other outlets for this valuable machinery, and since the production of spirituous liquors is essentially a fermentation process, the attention of the chemist should naturally be devoted to new developments along such lines. Thus the manufacture of lactic, butyric and citric acids could be still further developed together with special sugars such as maltose and food products derived from these, for example, lacto-maltose, etc. The manufacture of special sugars could also be undertaken and it is natural to assume that there will be a much increased demand for essential oils and flavoring extracts for the soft drink industry.

In the second place, one of the effects of prohibition will be to diminish the supply of fusel oil, in turn of amyl acetate, so that in all probability brewery equipment could be utilized for the manufacture of substitutes for these materials; in fact, certain cheap derivatives of lactic acid would form useful substitutes for amyl acetate.

Other Fields for the Chemist

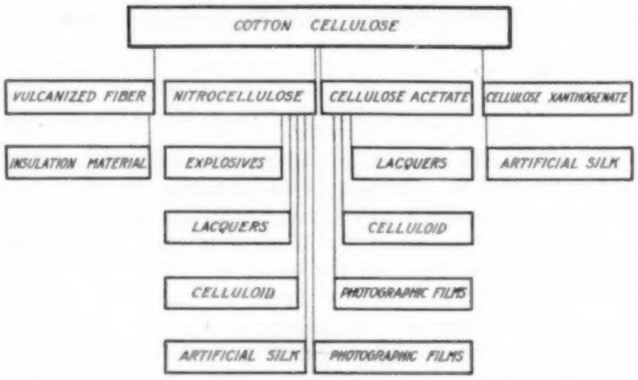
It is not possible to more than mention other fields in which the services of the chemical expert in aliphatic chemistry can find a suitable outlet such as utilization of acetylene, sulphite pulp waste liquor, and especially in the utilization of waste wood products, etc., but the diagrams shown herewith are of interest as indicating the varied outlets for one raw material, namely, cellulose. These show outlets already developed, but indicate little or nothing of the vast unexplored territory still remaining.

Thus, with regard to nitrocellulose and cellulose esters generally, there is a very fertile field for a series of investigations relating to the question of solubility of these products in organic solvents through which much light might possibly be thrown on such problems as the physico-chemical nature of solution, the colloidal state, the theory of partial valency, etc. All of these await in turn the development of some theory as to the structure of the cellulose molecule. The chemistry of the cellulose esters is as yet a com-

[11] *Journal*, Soc. Chem. Industry, Vol. 37, p. 425 (1918).
[12] *Journal*, Amer. Chem. Soc., Vol. 37, p. 1748 (1915).
[13] D. R. P. 241,853; 250,326.
[14] *Pharm. Weekblad*, Vol. 55, pp. 1426-31 (1918); Amer. Chem. Soc. Abstracts, Vol. 13, p. 262.

paratively unknown field, regarding which the industry is forced to rely almost entirely upon empirical data.

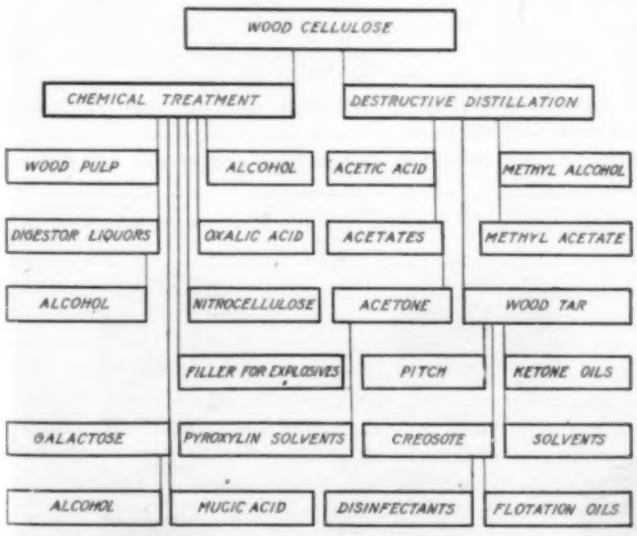
In another direction when we turn to the manufacture of celluloid in this country, the furtherance of the industry itself is dependent on the good will of the Japanese Government in selling us camphor. It would



seem imperative on the part of the American scientific chemist and chemical manufacturer to solve this problem by undertaking the manufacture of synthetic camphor or by carrying out a vigorous search for substitutes for this material, or by doing both. In this connection it would be of considerable assistance and value to the research chemist if the celluloid companies would be willing to explain for their benefit something with regard to the special and peculiar properties which a true substitute must possess.

The Wood Distillation Industry's Future

In the utilization of the constituents of the oils obtained from wood distillation, there is an interesting field of vast extent open to the research chemist. In view of the difficulty which will be experienced in obtaining raw material in Europe during the next twenty



or thirty years, it would seem that the wood distillation industry in this country is in an exceptionally favorable situation for development, and for the supply of products such as solvents for the varnish, artificial leather and lacquer industries; while as regards beechwood creosote, beechwood creosote carbonate, guiacol, etc., the country should be self-sustaining and not have to rely on foreign manufacture.

It is the function of the organic chemist to find outlets for the vast surplus production of aliphatic derivatives such as butyl alcohol, methyl alcohol, grain alcohol, acetone, etc., and to ascertain how far the new scientific facts developed during the last few years by the use of bodies such as phosgene, sulphur, chloride, aluminium chloride and of contact materials, for example, oxides of aluminium, thorium, nickel, etc., may be applied commercially.

In view of the extent to which the aliphatic compounds enumerated above enter into all of our daily life, the importance of a thorough study of these cannot be overemphasized. To assist in this the university and college teachers must of necessity themselves have learned to grasp the fundamental facts concerning the nature of these natural products so that their students may be trained to acquire the habit of thinking of such not merely in the light of formulæ made up of so many letters and strokes, but as combinations of different forms of energy capable of the most diverse transformations.

The old idea of fatty hydrocarbons as inert material must also be relegated to oblivion, and the mind directed to ascertaining how far such products, by the employment of better known catalytic and other methods, can be rendered valuable to the industry.

2 Rector Street,
New York City.

Good Flotation Oils From Crude Tar Products

The new "flotation" process for the concentration of various sulphide ores has had a rapid development in the last few years, and as a result the demand for flotation oils to use in the process has been very great. Pine oils and tar oils obtained by the distillation of Southern pine have become standard flotation oils, but the tar oils obtained by the destructive distillation of hardwoods have not been used so widely.

Recent investigations by the chemists of the Forest Products Laboratory, U. S. Forest Service and the Bureau of Mines have shown that several hardwood tar oils have a very high flotation value. Some of the crude tar products obtained in the ordinary operation for making wood alcohol made especially good flotation oils and in general these crude products were better than any of the redistilled oils obtained by further refining.

Zinc for Rail Bonding

The American Zinc Institute, in its campaign to increase the uses of zinc, is advocating spelter for rail bonding purposes. One of the largest street railway companies recently made a considerable purchase of spelter for use in the manufacture of its Nichols joints. Engineers in charge of bonding operations report that, viewed from price and adaptability standpoints, spelter is unexcelled for such work. Zinc is comparatively plentiful and relatively cheap, and in many directions it is satisfactorily taking the place of more expensive metals.

Decomposition of Metals

Owing to lack of space the second installment of the article on "Decomposition of Metals," by Col. A. J. Krynitzky, is omitted from this issue, but will appear at an early date.

Observations on So-Called "Flakes" in Steel

An Examination of Nickel Steel and Carbon Steel Transverse Test Bars Showed That Abnormalities in Fractures Were Associated With Impaired Physical Qualities and Exhibited More or Less Minute Slag Inclusions, While No Parallelism With Micrographic Characteristics Could Be Demonstrated

By HAAKON STYRI

MOST steel works which have produced war materials have had the annoying experience of getting rejections on account of low physical tests, particularly elongation and contraction, often associated with irregular spots in the fractures.

These irregularities are popularly known by the name "flakes," a name which may serve the purpose when meant to include all types of irregular spots in fractures, but is poor terminology when used for certain types without further qualification. Some accompanying pictures of fractures will show different types of such "flakes." We have small bright spots of a fine crystalline mass radiating from a kernel (Fig. 1), coarse crystalline shiny, leafy spots, the so-called "snowflakes" (Fig. 2), fibrous laminated spots (Fig. 3), smooth velvety bright spots (Fig. 4), flaws and holes (Figs. 5 and 7), and sometimes no distinct spots, but the whole fracture, indicating "rotted" material (Fig. 8).

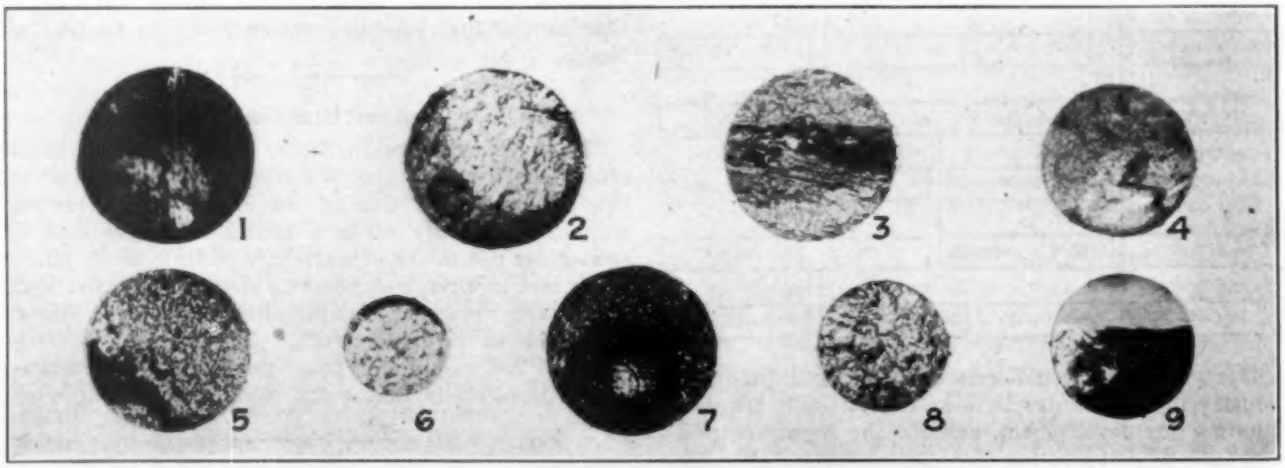
Flakes have mostly been noticed in transverse test bars from nickel steel, but are also found in other classes of steel, and there is a multitude of opinions as to their cause, ascribing them to the melting, the casting, the forging, the heat treatment, or to any combination of these operations. That no single theory covers the whole problem is evident, since flakes still are very frequent in spite of all the work that has been done to eliminate them. So far it seems fairly well established, however, that the ordinary chemical analysis of the heat does not indicate whether flakes will occur in test bars or not.

The present notes, which are very far from being complete, owing to the difficulties of securing research material during war time and the limited time at the author's disposal in which to prepare the samples, perform the microscopic examination and the photographic work, are presented in the hope that they will throw some additional light on the problem. With the effective and untiring help of Prof. F. Crabtree of the Carnegie Institute of Technology, the author succeeded in getting most of the research material from several interested steel companies, and a little from inspectors of ordnance for the Army and Navy. In the paper, the sources are named "party A," etc., because the companies do not want their names mentioned. The different nickel steels were made in electric, acid, and basic open-hearth furnaces; the carbon steels were made in an acid open-hearth.

Microstructure Inconclusive

Microstructure of the first samples of test bars from party A sent to the author for examination are shown in Figs. 10, 11 and 12, which show respectively the fractures of a nickel steel test bar with a good normal cup fracture, and of rejected bars with an irregular and a fibrous laminated fracture. Information on the exact heat treatment could not be obtained, but was thought to be practically the same, while the chemical composition of the steel is identical. Figs. 13 and 14 give the microstructure of a similar nickel-steel with another heat treatment and representing respectively the structure of a test bar with good cup fracture and of a rejected bar with an irregular fracture.

The metallographic analysis showed that different kinds of microstructure (and therefore heat treatment) have no influence on the actual occurrence of flakes.



FIGS. 1 TO 9. VARIOUS TYPES OF ABNORMAL FRACTURES

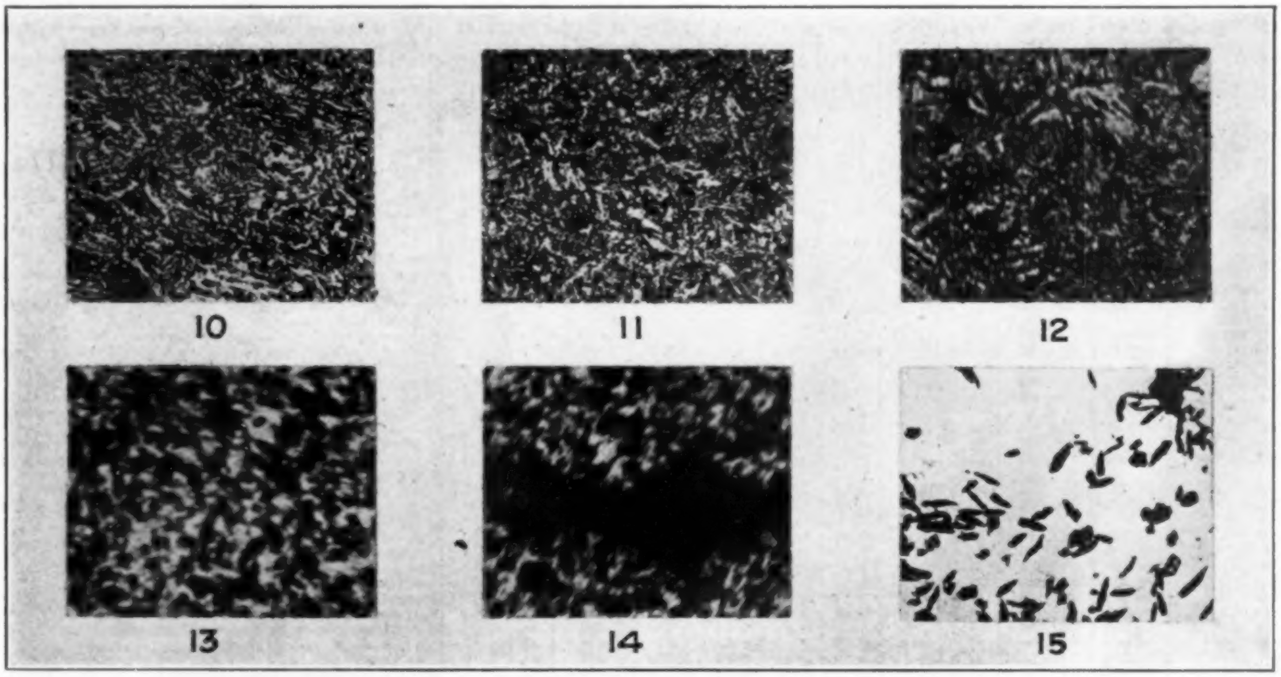
Fig. 1. Fracture of bar 218 from party B, with bright radiating flake. × 2. Fig. 2. Fracture of bars from party D; coarse-crystalline shiny "snowflakes." × 2. Fig. 3. Fracture of carbon steel bar 2399-2 from party G, with fibrous laminations. × 2. Fig. 4. Fracture of carbon steel bar 234 II from party F, with velvety flake. × 2. Figs. 5 and 6. Fractures of two adjoining test bars from piece 3872 furnished by party F; Fig. 5 shows flaws; Fig. 6 is normal cup fracture; see Table VI for physical properties. × 1.5. Fig. 7. Spherical flaw, crystalline in center, bar 3070 D, from party F. × 2. Fig. 8. Fracture of "rotted" metal in 55G1 from party F. × 2. Fig. 9. Shining, smooth flaw probably from an unwelded blowhole in M53D from party F. Smooth part is polished back for microscopic examination. × 2.

Flaky test bars and good test bars with cup fracture are both found with practically the same microstructure, which can be: pure sorbite, fine ferrite network with sorbite, coarse ferrite network with Widmanstättian structure, and with different kinds of sorbite, or ferrite with pearlite. But examples were found that show an improvement in the quality of the steel with proper heat-treatment, which, however, has not eliminated the flakes.

No Nickel Silicates in Nickel Steel

When an opportunity was given the author to examine the fresh fracture of rejected test bars with a binocular microscope it was found that the fractures showed a considerable amount of green slag particles. With this as a clue, I tried to ascertain the nature of such inclusions by microchemical analysis, which proved to be a very difficult matter because the slag particles were so very small. In the literature, it has been generally assumed that these faulty fractures mostly occur in nickel steel, and it was therefore thought probable that the slag particles might be some nickel silicate, and considerable effort was given to discover whether the slag particles contained nickel or not. Some slag particles were picked out of the fracture, under the microscope, by means of a fine needle, dissolved in HF or fused with Na_2CO_3, and a concentrated drop of the final solution tested with diphenylglyoxime, which gives a very sharp test for minute quantities of nickel, but no sign of nickel could be found.

In the expectation that at least some of the slag particles present in the steel would not go in solution, about 20 g. of a flaky bar was dissolved in 1 : 3 HCl on the hot bath and the residue filtered. It was found in several trials that the precipitate on the filter consisted of small distinct slag particles together with flocculent silica and MnO_2 and it was difficult to separate these masses. For separation a small flotation apparatus of glass tubing was blown and tried with some advantage, but the best method was to brush the dried filter with a fine brush whereby the larger slag particles could be taken off. Alundum crucibles for filtering also served the purpose well. Filtering on "ashless" filter, burning it and trying to determine the residue under the mineralogical microscope was not successful because the ashless filter contained too many crystalline substances. Good silk filters were much better, and with them it was found under the mineralogical microscope that the slag particles were of a glassy nature. Fig. 15 shows the slag particles found in 20 g. of steel. Testing for nickel with this larger mass gave no indication. But it was found that fusion with KNO_3 and Na_2CO_3 gave a strong reaction for Mn and it was also found that iron and SiO_2 were present. A test showing presence of calcium in concentrated solution might be mentioned, but it is possible that the glass flask was dissolved, and there has been no time to check this result.



FIGS. 10 TO 15

Fig. 10. Accepted bar with cup fracture, from party A. HNO_3 etching. × 300. Fig. 11. Rejected bar, with irregular fracture, from party A. HNO_3 etching. × 300. Fig. 12. Rejected bar with fibrous fracture, from party A. HNO_3 etching. × 300. Fig. 13. Accepted bar with cup fracture, from party A. HNO_3 etching. × 100. Fig. 14. Rejected bar with irregular fracture, from party A. HNO_3 etching. × 200. Fig. 15. Iron and manganese silicate slag particles remaining after solution of 20g. nickel steel, from party A. × 20.

These tests show at least some of the inclusions to be manganese silicates, which only confirms the work of others and the more important fact that no nickel-silicate is present. It is clear that on dissolving steel in acid, inclusions like MnS or very limy silicates will go into solution, and the pressure of such slag particles in the fracture can only be proved directly under the microscope or by the tedious and difficult method of picking them out and analyzing them microchemically.

Importance of Slag Inclusions

It was concluded that in the test bars from party A the slag inclusions played an important rôle in causing low physical tests, but it was, of course, of interest to find whether the same source for the trouble could be found in test bars from other concerns.

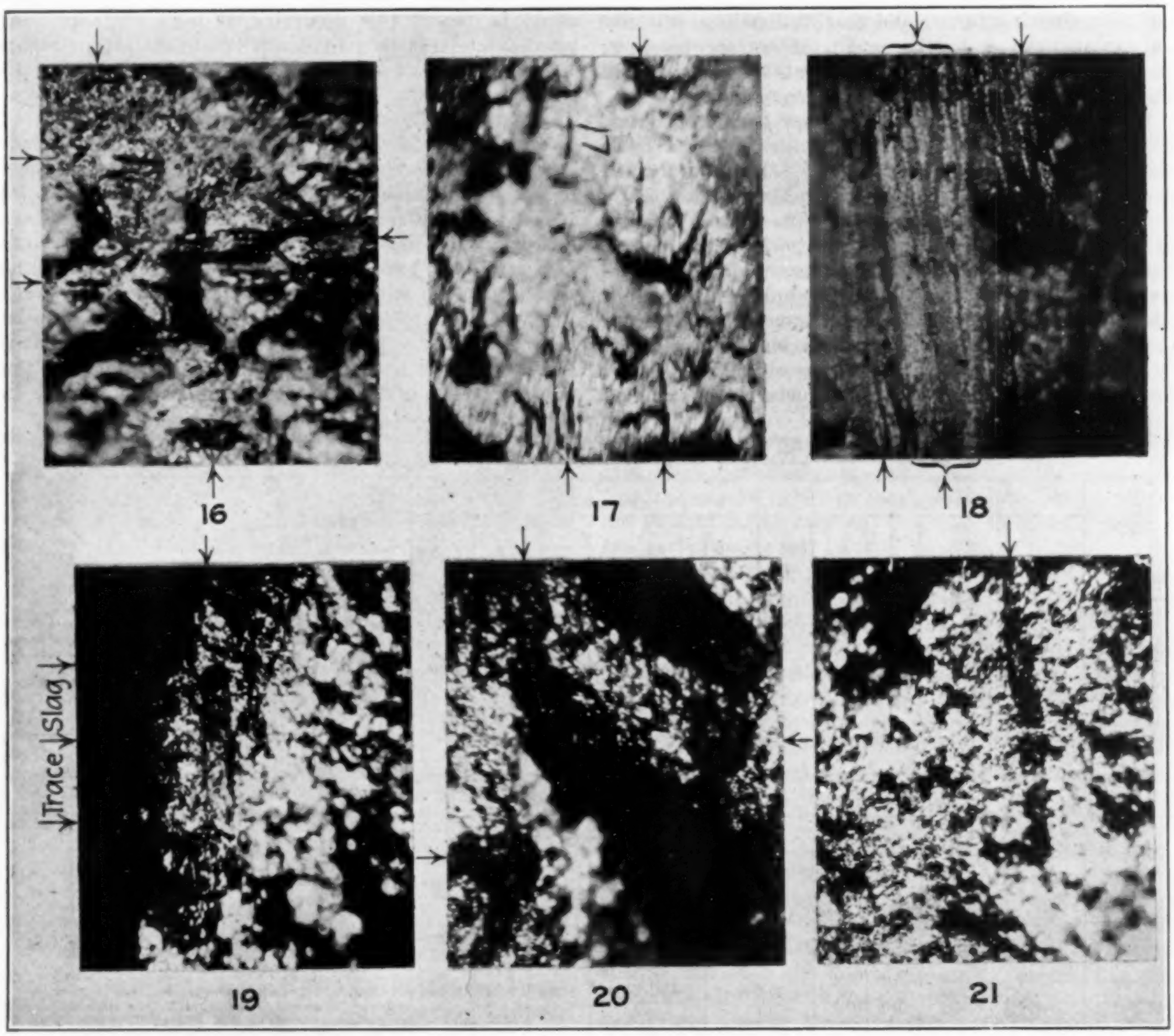
TABLE I—DESCRIPTION OF NICKEL STEEL TEST BARS FROM PARTY B

Test Bar Mark	Physical Properties: Elastic Limit	Ultimate Strength	Elongation	Reduction in Area	Analysis: C	Mn	Si	S	P	Ni	Cr	Description of Fracture
720 B20	71,000	108,000	10.5	13.3	....	....	....	....	....	....	....	Very many dark green inclusions in bright spots.
720 MT2M	58,000	95,000	15.0	20.2	....	....	....	....	....	....	....	Very many dark green inclusions in bright spots.
218 TD	73,000	100,500	15.0	21.6	....	....	....	....	....	....	....	Very many inclusions in ¾ of fracture, light green in color.
293 T1B1	77,000	108,500	10.5	17.0	0.47	0.60	0.14	0.029	0.039	3.26	....	Very many dark green inclusions in bright spots.
773 BT3O	75,000	106,500	15.0	16.2	0.31	0.55	0.09	0.021	0.032	2.90	0.27	Very many inclusions in bright spots. Some big yellow inclusions; also traces. Inclined fracture.
947 BT2M	70,000	106,000	14.0	20.5	0.33	0.59	0.09	0.026	0.028	2.63	0.13	Very many yellow inclusions in bright spots. Many traces. Many dark and yellow inclusions.
847 MT3M	69,000	107,000	15.0	22.3								
864 BT1	68,000	105,500	13.5	34.0	0.40	0.53	0.14	0.030	0.020	2.85	0.21	Many dark and yellow inclusions in bright spots.
218 B	68,000	99,000	6.0	2.7	0.36	0.62	0.11	0.027	0.032	3.25	....	Many dark and yellow inclusions in bright spots. Bad fracture.
815 BT2M	65,000	92,000	8.0	4.8	....	....	....	....	....	....	....	Many yellow inclusions in small bright spots and some dark green inclusions in larger bright spots.
864 MT1M	64,000	104,400	17.0	28.0	0.40	0.53	0.14	0.030	0.020	2.85	0.21	Many yellow inclusions in bright spots. Traces.
848 MT1M	62,000	91,500	12.0	30.8	0.33	0.59	0.09	0.026	0.028	2.63	0.13	Many thin inclusions, yellowish, green and dark, mostly in bright spots.
783 BT1M	66,000	98,000	17.5	33.4	0.38	0.58	0.09	0.036	0.018	2.29	0.16	Many thin, dark inclusions. A few yellow inclusions in bright spots.
783 MT1M	67,000	107,000	16.0	21.7								Many yellow inclusions. Many traces in bright spots Fracture inclined.
823 MT1M	87,000	115,500	10.0	13.3	0.36	0.65	0.10	0.029	0.026	2.89	0.30	Many inclusions, some large and green. Traces in bright spots.
824 BT1I	85,000	110,500	12.0	28.5	0.33	0.53	0.10	0.026	0.018	2.60	0.16	Many inclusions in bright spots. A large green inclusion. Several traces.
848 BT2M	62,000	95,000	20.5	32.1	0.33	0.59	0.09	0.026	0.028	2.63	0.13	Several small dark inclusions in bright spots.
873 BT1O	68,000	102,500	18.0	30.8	0.32	0.57	0.13	0.013	0.031	2.89	0.06	Several green inclusions in bright spots; also traces inclined fracture.
823 MT2M	92,000	117,000	16.0	38.5	0.36	0.65	0.10	0.029	0.026	2.89	0.30	Several inclusions in bright spots. Traces.
773 BT1O	70,000	100,500	19.5	34.7	0.31	0.53	0.09	0.021	0.032	2.90	0.27	Several small green inclusions in center of fracture.
817 BT2I	103,000	125,000	15.2	40.3	0.34	0.54	0.18	0.026	0.021	2.52	0.25	Several yellow inclusions, many traces, mostly in center of fracture.
861 BT2I	80,000	106,000	16.5	34.7	0.39	0.64	0.13	0.017	0.021	2.55	0.15	Several yellow inclusions, many traces.
783 MT4M	60,000	101,500	15.5	25.7	0.38	0.58	0.09	0.036	0.018	2.29	0.16	Some slag particles; many traces.
864 MT2	66,300	103,300	19.5	37.3	0.40	0.53	0.14	0.030	0.020	2.85	0.21	Some small yellow inclusions in bright spots in center of fracture.
864 BT2M	67,000	105,500	16.5	40.9								Some small inclusions; several traces in bright spots.
819 MT2M	80,000	111,500	18.0	46.3	0.38	0.55	0.07	0.021	0.018	2.58	0.25	Some yellow inclusions and several traces in center of fracture.
815 BT1M	66,000	106,400	15.0	29.0	....	....	....	....	....	....	....	Some big yellow inclusions and several small inclusions in bright spots.
218 TM7A	80,000	106,000	20.5	44.8	0.36	0.62	0.11	0.027	0.032	3.25	....	Some small dark inclusions and traces. Old fracture.
259 BT5M	83,000	106,000	19.0	45.3	0.40	0.70	0.10	0.030	0.035	3.10	....	Some dark and yellow inclusions. Several traces. Fracture inclined.
785 MT1M	90,000	116,000	19.0	40.3	0.38	0.55	0.09	0.026	0.027	2.76	0.22	Some small yellow inclusions; several small traces.
861 BT1M	76,000	106,000	18.1	44.6	0.39	0.64	0.13	0.017	0.021	2.55	0.15	Some yellow inclusions. Several traces, some of them large.
783 MT2M	67,000	110,500	18.0	37.2	0.38	0.58	0.09	0.036	0.018	2.29	0.16	A few small yellow inclusions. Old fracture.
815 BT3M	66,000	106,500	16.5	42.7	0.40	0.55	0.12	0.027	0.020	2.64	0.32	A few small inclusions and a few traces in bright spots.
819 BT2M	83,000	110,500	24.5	49.1	0.38	0.55	0.07	0.021	0.018	2.58	0.25	A few yellow inclusions and some traces in center of fracture.
780 BT2M	68,000	95,500	20.0	46.3	0.32	0.50	0.07	0.021	0.024	2.52	0.17	A few yellow inclusions and several traces.
831 BT1I	85,000	100,500	19.0	47.7	0.37	0.57	0.10	0.025	0.023	2.88	0.25	A few small gray inclusions in white spots and a few traces.
850 MT1I	85,000	111,000	19.5	46.3	0.40	0.56	0.11	0.030	0.020	2.82	0.13	One small dark inclusion. Thin traces.
825 MT1I	93,000	115,500	21.0	49.1	0.35	0.57	0.13	0.015	0.015	3.30	0.15	One small yellow inclusion. A few traces.
840 MT1	84,000	113,000	18.2	50.5	0.38	0.50	0.07	0.017	0.026	2.70	0.11	One small black spot. A few traces.
819 MT1M	88,000	113,000	18.0	49.1	0.38	0.55	0.07	0.021	0.018	2.58	0.25	One small yellow inclusion. A few traces.
817 T1M	86,000	115,500	18.5	46.3	0.34	0.54	0.18	0.026	0.021	2.52	0.25	Several traces and possibly some yellow slag.
815 MT3M	69,000	115,500	18.5	41.8	0.40	0.55	0.12	0.027	0.020	2.64	0.32	Fair but old fracture. Possibly a few traces.
864 MT2M	66,300	103,300	19.5	37.3	0.40	0.53	0.14	0.030	0.020	2.85	0.21	A few traces in a bright spot. Inclined fracture.
266 T1F	58,000	65,000	23.0	40.3	0.50	0.63	0.21	0.021	0.036	3.40		No inclusions. Some small traces.
796 MT1M	85,000	111,500	19.0	49.1	0.39	0.55	0.11	0.020	0.021	2.86	0.10	Small traces.
846 MT2I	74,000	102,500	19.5	55.9	0.37	0.58	0.11	0.029	0.020	2.61		Some small traces. Good fracture.
826 MT4M	92,000	117,000	17.0	43.3	0.35	0.57	0.13	0.045	0.015	3.30	0.15	Some deep traces. Fracture inclined.
846 MT1I	76,000	105,500	20.0	54.6	0.37	0.58	0.11	0.029	0.020	2.61	....	No inclusions. A few small traces.
873 BT6M	63,000	94,000	16.5	38.8	....	....	....	....	....	....	....	Two or three small bright spots.
930 MT1M	64,000	97,000	23.0	53.3	....	....	....	....	....	....	....	Two or three small bright spots with dots of slag.
919 BT1M	72,000	105,500	21.0	49.1	....	....	....	....	....	....	....	Two or three small bright spots.
888 MT1M	91,000	116,500	19.0	46.3	....	....	....	....	....	....	....	A few small traces.
804 BT1I	87,000	108,500	20.0	51.9	....	....	....	....	....	....	....	A few small traces.
887 BT2M	61,000	98,000	22.0	47.7	....	....	....	....	....	....	....	One small green inclusion.
881 MT3M	69,000	105,500	23.0	53.5	....	....	....	....	....	....	....	One small green inclusion.
931 BT2I	76,000	108,500	19.0	50.5	....	....	....	....	....	....	....	A trace.
927 MT2M	73,000	105,500	21.0	46.3	....	....	....	....	....	....	....	No inclusions.
922 MT1M	75,000	107,000	23.0	55.9	....	....	....	....	....	....	....	No inclusions.
895 MT6M	68,000	99,500	24.0	57.3	....	....	....	....	....	....	....	No inclusions.
217 BTL	77,000	103,000	19.5	59.8								No inclusions. Good but old fracture.
218 BR	72,000	103,000	24.0	57.3	0.36	0.62	0.11	0.027	0.032	3.25	....	No inclusions. Good but old fracture.
217 B1I	77,000	103,000	19.5	59.8								No inclusions. Good star fracture, but old.

The opportunity was given to examine with the binocular microscope numerous freshly broken samples from party B. Examination was done in the following manner: Test specimens were taken serially as they were placed in the rack, their numbers noted, and the fractures examined with different magnifications. Corresponding remarks were jotted down describing as briefly as possible the general characteristics of the fracture, giving an idea of the number, color, and mode of occurrence of the slag particles. In some of the fractures some shining streaks called "traces" were also noticed, probably matrices from which slag had fallen; this could sometimes, but not always, be ascertained.

When this listing was finished the samples were then grouped according to the number of slag inclusions and the physical data were added (Table I). Study of this will show that there is a striking general connection between the number of slag inclusions and the elongation and contraction; but the elastic limit or tensile strength seems not to be affected.

Great pains was taken in the examination of the fractures of test bars with the binocular microscope, whereby a first approximate quantitative proof can be given of the influence of the slag inclusions on the physical qualities of steels with practically the same heat treatment, and particularly on the elongation and



FIGS. 16 TO 21. SLAG INCLUSIONS IN DEFECTIVE FRACTURES, BOTH NICKEL AND CARBON STEELS

Fig. 16. Lenticular slag inclusions in 823MT1M, from party B. × 20. Fig. 17. Lenticular slag inclusions in 847BT2M, from party B. × 20. Fig. 18. "Traces" or cavities from which slag has fallen, from party C. × 20. Fig. 19. Large slag inclusion in sample 4 from party D, with "trace" extending to right. × 20. Fig. 20. Round slag exposures in longitudinal test of carbon steel 210P from party F. × 55. Fig. 21. Streak of slag in transverse test of carbon steel 55G1, from party F. × 15.

contraction. It is most striking to find that in all good test bars examined either no slag particles or only very small round particles or traces of them are found.

It must, however, be taken into consideration that there is some variation in the mechanical tests because of variation in chemical composition and heat treatment, which latter is supposed to be practically constant, but is subject to the influence of shop conditions. The effect of different heat treatments, however, is practically excluded in six tests from the same forging (No. 843*), showing that the results differ both in breech end and muzzle end corresponding with the number of slag inclusions. The typical fracture of the poor bars of Table I is shown in Fig. 1, and photographs of the slag inclusions taken with the binocular microscope are shown at 20 magnifications in Figs. 16 and 17. A similar photograph of flaky fractures of bars from party C are shown in Fig. 18 and from party D in Fig. 19. No data on the bars from F were available. These photographs cannot, of course, all be in focus, as the fractures are too irregular. It is important to note the importance of good illumination for the microscopic examination. Sometimes diffused sunlight, at other times a strong daylight lamp is the best, depending on the color of the slag. As high a magnification as 80 is ordinarily necessary, but it sometimes happens that the slag can be seen with the naked eye.

MICROGRAPHIC EXAMINATION

The microstructure of some of the bars in Table I was examined carefully. We could suspect the banded structure of the light and dark sorbite with Widmanstättian lines shown in Figs. 22 and 23 to be the cause of the poor result of test bar 720 BT2O, but we find a similar structure in the good bar 873 BT6M (Figs. 24 and 25) and less distinctly in 895 MT6M, both of which have a good cup fracture. The microstructure in Fig. 26 of Sample No. 107, with the rather surprising physical test of elastic limit 80,000, tensile strength 95,500, elongation 23 per cent, reduction in area 69

*Analysis:

C	0.40 per cent	P	0.031 per cent
Mn	0.63 per cent	Ni	2.88 per cent
Si	0.10 per cent	Cr	0.30 per cent
S	0.035 per cent		

per cent, showing ferrite and pearlite banding, will give an explanation as to the origin of sorbite banding; it is simply that the heat treatment has not brought the solid solution to a condition of homogeneity.

Fractures of some nickel steel test bars from party D were now examined and the results given in Table III. The "flakes" in these fractures (shown in Fig. 2) are larger and more coarsely crystalline, with a leafy aspect instead of with a radiating fine grain as most of those in Table I. Some of the worst fractures can hardly be explained by the small amount of slag inclusions, as can be seen from a study of the table. The microstructure of D6 at the intersection between the flake and a plane meeting at a blunt angle (such as in Fig. 9) shows fine uniform sorbite, and a very small patch of Widmanstättian structure was all that could be found, this occurring at some distance back of the intersection. Evidently Widmanstättian structure could not have caused the flake in this case.

INTERNAL CRACKS

With but little slag in the fracture and no abnormalities in the microscopic appearance, the cause of these defective fractures remained undecided until more nickel steel bars from party E were obtained. These are listed in Table IV. The fracture of bar No. 681 shows a crystalline "snowflake," and No. 230 a crystalline fracture coated with oxide, evidently formed in a crack in the steel, probably in the heat-treating furnace or during forging. The microstructure of 681 (cut at a slight angle with the flake) is shown in Fig. 27, the microstructure of 230 (cut perpendicularly to flake) in

TABLE II—TABULATION OF CHARACTERISTICS OF FRACTURES FROM FORGING 843

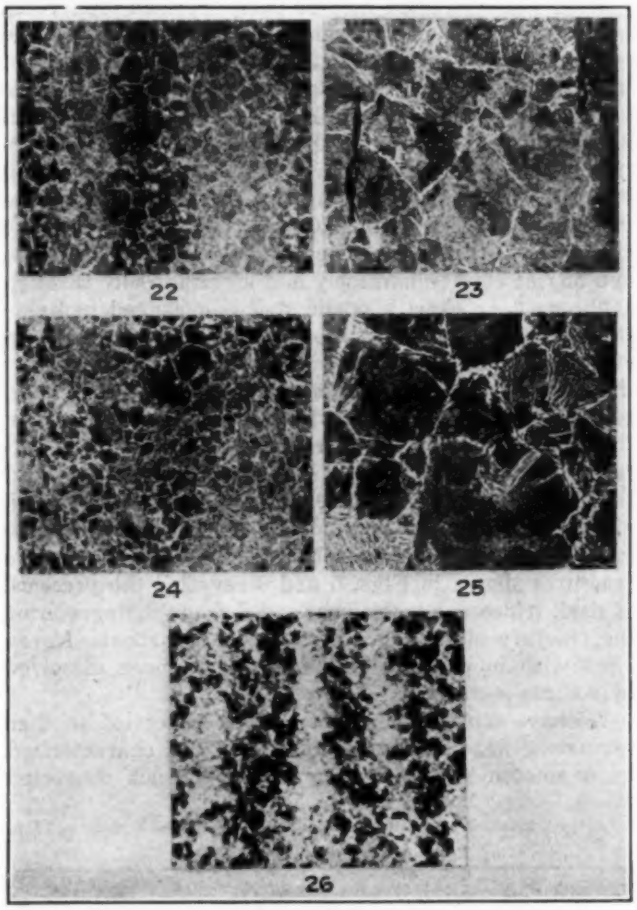
Test Bar Mark	Physical Properties				Analysis							Description of Fracture
	Elastic Limit	Ultimate Strength	Elongation	Reduction in Area	C	Mn	Si	S	P	Ni	Cr	
843 MT2M	75,000	107,000	13.0	22.3	0.40	0.63	0.10	0.035	0.031	2.88	0.30	Many inclusions, some large and yellow. Traces.
843 BT1M	69,500	103,900	18.0	35.3								Many very small dark inclusions in small bright spots.
843 MT4M	71,000	105,000	11.0	5.8								A big bright spot with dark inclusions. One very big dark slag spot outside this. Several traces.
843 MT5M	70,000	107,500	21.0	47.7								One yellow inclusion in bright spot. Good fracture.
843 BT4M	66,000	99,500	22.0	51.9								A trace. Good fracture.
843 MT3M	69,000	103,000	22.5	50.5								A few small traces. Good fracture.

TABLE III—TEST BARS FROM PARTY D

Test Bar Mark	Physical Properties				Analysis							Description of Fracture
	Elastic Limit	Ultimate Strength	Elongation	Reduction in Area	C	Mn	Si	S	P	Ni	Cr	
1	58,000	89,600	0.0	0.0	0.39	0.49	0.13	0.018	0.009	3.01	0.24	A small bright spot with dark green slag inclusion. Outside of spot are large and many small traces.
2	71,000	90,700	0.0	0.0								One-tenth area a bright spot with a dark green slag inclusion. Outside this the fracture is laminated and has slag streaks and many shining white traces.
3	59,000	76,500	0.0	0.0	0.39	0.63	0.21	0.012	0.016	2.77	0.39	Three bright shining crystalline spots without inclusions. A few yellow particles found in remaining half of fracture.
4	58,000	97,250	10.0	0.0	0.30	0.55	0.22	0.024	0.018	2.90	0.42	Angle fracture. Small bright spot on one side with a large green inclusion. A few slag particles outside spot.
5	56,000	65,000	0.0	0.0								One-third area a shining bright spot, coarsely crystalline, with no slag. Several large traces outside spot.
6	57,000	67,550	0.0	0.0								Two-thirds area a bright spot without inclusions. A few small traces of slag outside spot.

TABLE IV—NICKEL STEEL BARS FROM PARTY E

Test Bar Mark	Physical Properties				Analysis							Description of Fracture
	Elastic Limit	Ultimate Strength	Elongation	Reduction in Area	C	Mn	Si	S	P	Ni	Cr	
230 MT3I	47,000	47,030	0.0	0.0	0.38	0.69	0.24	0.033	0.043	3.25	....	Irregular fracture mostly covered with coat of scale. Bright part is crystalline with some slag streaks
681 BT1M	45,000	45,250	0.0	0.0	0.40	0.58	0.17	0.029	0.054	3.00	....	Four-fifths of surface is an irregular coarse crystalline bright spot with a few large patches of green slag inclusions. Smaller slag streaks along edge of flake.
564 BT1M	60,000	69,000	2.5	3.0	0.42	0.70	0.27	0.030	0.045	2.75	....	One-third of fracture irregularly coarse crystalline with a large patch of light green slag. No inclusions found in rest of fracture, which is fine crystalline.
632 MT1M	72,000	93,750	6.0	7.0	0.38	0.68	0.16	0.030	0.047	3.04	....	Three small bright coarse-crystalline spots. Streaks of slag and laminations near spots. Balance of fracture fine crystalline with no inclusions.
5512 BT1I	62,000	100,600	14.0	19.1	0.36	0.53	0.20	0.029	0.046	3.00	....	Half of fracture is bright spot, irregularly coarse—crystalline in center, surrounded by porous area with a few small dark slag streaks. Balance of fracture fine crystalline and slag-free.
5943 BT1I	61,000	94,500	10.5	16.6	0.40	0.57	0.22	0.030	0.046	3.22	....	One-fifth area a bright spot whose center is coarsely crystalline and white. Radiating structure from here to adjoining angular fracture. No inclusions.



FIGS. 22 TO 26.

Fig. 22. Banded sorbite in defective bar 720 BT2O, from party B. HNO_3 etching. × 25. Fig. 23. Same as Fig. 22. × 100. Fig. 24. Banded sorbite in accepted bar 873 BT6M, from party B. HNO_3 etching. × 25. Fig. 25. Same as Fig. 24. × 100. Fig. 26. Non-homogeneity in 107 from party B. HNO_3 etching. × 50.

Fig. 28, the latter showing a crack in a fine sorbite-structure and with no slag; a nearby crack, however, passed through small slag particles.

It seemed possible, therefore, that the cause of these flakes could be the cracking or incipient cracking of the steel previous to testing. To further illustrate this question a cold-broken part of a gun-tubing from party C shown in Fig. 29 was examined. Round coarse-crystalline "snowflakes" are here found separated by fibrous structure. Transverse (a — a) and longitudinal (b — b) sections of this broken part were polished and etched with the Stead-Le Chatelier reagent, and are shown in Figs. 30 and 31. There is no difference in the microstructure near the snowflakes and near the fibers, nor did the microstructure show any difference. In the longitudinal section (Fig. 31) it can be plainly seen how the dendrites run straight across the crater of a "snowflake." On its side the crater showed evident shearing.

Etching this tube a long time in strong acid revealed deep seated, fine cracks, running approximately radially and in the direction of the forging. Microscopic examinations of this sample as well as of samples 3 and 6 from party D and 681 from party E show no relation between the grain-size of the flaky fracture and the ferrite network of the microstructure. In sample 6 there is hardly any network visible, and 230 has none at all (Fig. 28). Where ferrite network was found, the grains exhibited in the fracture were much coarser than those in the crystalline network, so the crack or fracture must have gone through two or more crystals, irrespective of grain boundaries.

It is known that acid etching of forgings very often reveals deep cracks which may cause flakes; but often flaky test bars are found in sections where no cracks are found on etching. It is of interest to find whether a difference in structure would be the cause for the etching cracks. The author has made a few tests on deep etching for cracks which was done after the specimens had been carefully polished and lightly etched for development of microstructure. He has not found, so far, that the acid produces cracks where none were found in the microstructure. Where slag particles were situated, however, the acid generally left deeper etching pits, which is natural, because the acid gets a larger surface to attack after the acid has dissolved the slag, either directly or by dissolving the material around it. It seems, therefore, reasonable to assume that the cracks noted in the examination of flaky bars are present in the forging; they may have been original cracks in the ingot, or may have been formed in the subsequent heating and forging.

Kilby[1] has shown that improper pouring or pouring at too high or too low temperatures will cause cracking in the ingot. But there has been an endless discussion about the influence of the mold on the cracking and about which form of mold best will prevent cracking. To the author the main reason for cracking seems clear, considering the fact on which Driessen[2] has given numerical data, that steel, cooling and contracting from high temperature, has a period of expansion corresponding to the transition range. When the ingot cools, the outside layers will have expanded while the inner is still hot, and be less ductile when the interior layers expand, whereby the surface may start to crack. The author has noticed such cracking proceeding several days after the casting of large ingots. It is natural that it should start where the outer cold skin is the thinnest—for instance in the grooves of fluted ingots and in the sides of squares and polygons. On the other hand, the columnar structure of the surface layers might induce cracks leading in from the corners, because the weakest planes are to be found where the columns from different directions intersect, and where we also find most of the segregated impurities. Surface cracks must, however, be coated with oxides and are not the same as cracks in the inner parts of the steel, which on fracture are perfectly shiny and crystalline. Such cracks must have been formed by improper heating or forging whereby the surface has been stretched more than the inside can follow, or they may have their origin in blowholes which are not completely welded.

BLOWHOLES AND FORGING FLAWS

A sample of such unwelded blowhole in a fractured test piece is shown in Fig. 9, where the smooth shining surface of the flake leaves no doubt as to its nature. The polished section cut through the blowhole did not show any difference in microstructure of the flake and the material back of it, all being sorbitic. That blowholes do not necessarily weld at high temperatures can easily be shown by "forging" molding wax in which holes are made.

It is an absolute necessity that the surfaces touch

[1]*Journal*, Iron & Steel Institute, 1917, Vol. II, p. 69; *Engineering*, 1918, p. 34.

[2]*Ferrum*, Vol. II, p. 129.

when they are to be welded, and holes do not close before a certain reduction is performed. The temperature must, besides, be sufficiently high for welding, as shown by Stead[3].

A sample from soft steel used in a demonstration of improper hot forging practice was kindly furnished the author by J. S. Taylor of the Carnegie Institute of Technology and is shown in Figs. 32 and 33. The cracks have their principal direction radially, which is natural since the strain that has produced them goes at right angles to the direction of blows of the hammer or press when flat dies are used. It is clear that slag inclusions when forged will help to start such cracks, because they leave sharp angles in the strained material.

Flakes in Carbon Steels

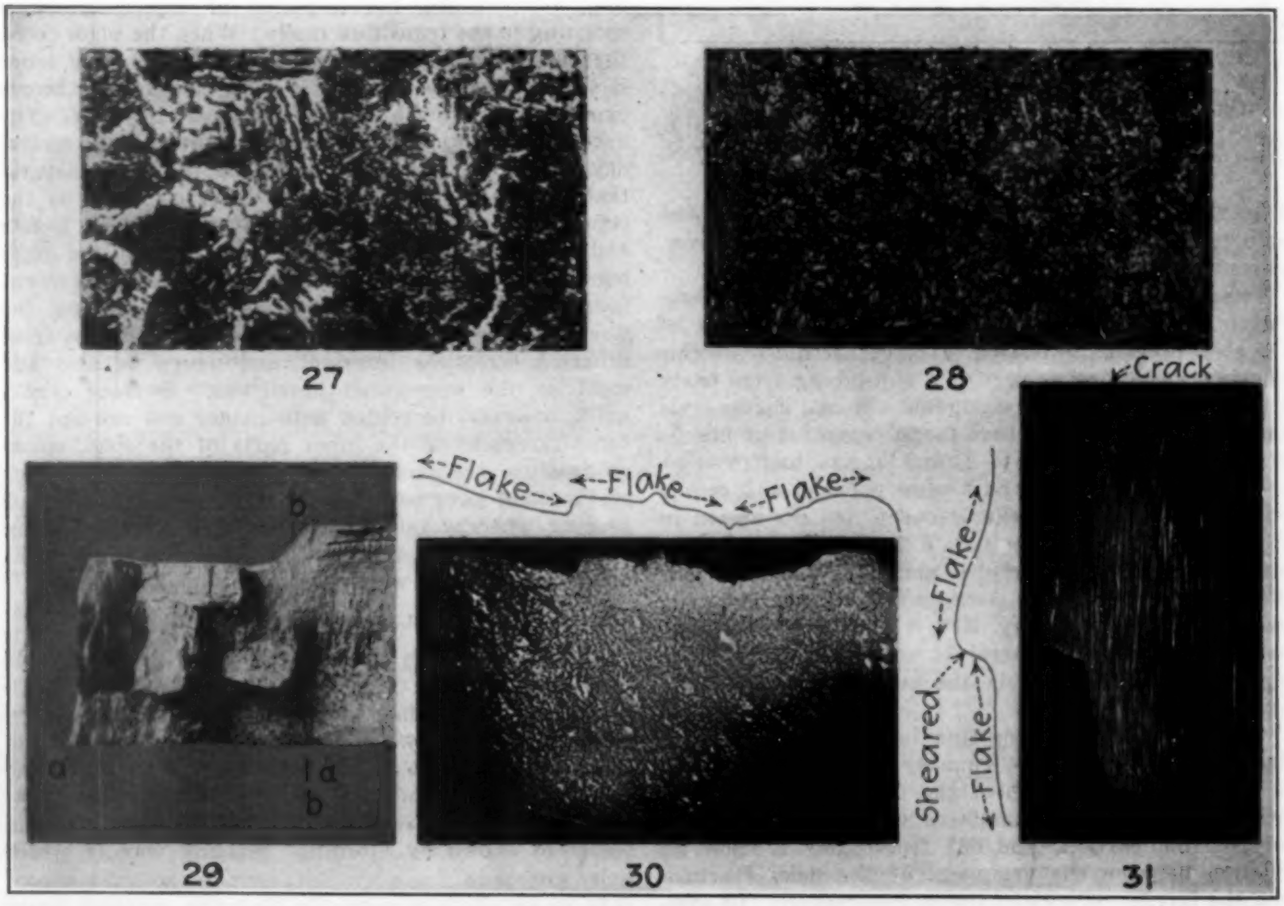
In the examination so far made on nickel steels, I have practically always found slag inclusions associated with the flakes. It was considered probable that such inclusions would have the same effect on ordinary carbon steels, where the more scant occurrence of flakes must partly be ascribed to the fact that test bars are more generally longitudinal and seldom transverse for these types of steel. The larger section of a slag particle flattened in the direction of work and the sharp angle it cuts in the steel matrix must naturally show a greater effect in the results of testing transverse pieces.

With the interested help of party F, such transverse tests were made of different carbon steels with some corresponding longitudinal tests, and the results given in Tables V and VI. The flakes in these bars are more variable and are shown in Figs. 4 to 9 inclusive. The flaky test pieces showing the poorest physical properties are those containing large masses of slag (No. 210 P and 55), the slag showing up as round spots in the longitudinal tests (Fig. 20) and as streaks in the transverse (Fig. 21). The microstructures (Figs. 34 and 35) of cuts transversely and longitudinally through a fibrous flake show how the slag is arranged in light-colored streaks following the fibers. Fig. 36 gives microstructure containing many slag inclusions found near the peculiar spherical crater in 3070 (Fig. 7). The tests of greatest interest in Table VI are, perhaps, those of the two bars marked 3872 F, cut from adjacent parts of the forging, one giving a good test and the other a rotted fracture, breaking under the head along a crack which was declared by party F to be caused by cracking in quenching. Examination of these fractures shown in Figs. 5 and 6 revealed the presence of dark iridescent inclusions, and a microphotograph of the fracture-edge (Fig. 37) shows a decarbonized area filled with holes from which MnS had been dissolved by sodium-picrate[4].

We have exhibited in Table VI the effects of another variant of flake illustrated in Fig. 4 and characterized by a smooth round shining silky spot not connected

[3]*Journal*, Iron & Steel Institute, 1911 and 1912.

[4]After Comstock's method; *Journal*, Iron & Steel Institute, 1916.



FIGS. 27 TO 31

Fig. 27. Bar 681 from party E, slightly inclined to crystalline "snowflake." HNO_3 etching. × 300. Fig. 28. Bar 230 from party E, perpendicular to oxidized spot in fracture. HNO_3 etching. × 300. Fig. 29. Fractured gun tube from party C. Three flakes intersect the surface between *a* and *a*, while a fourth is at the center at section *b-b*. Natural size. Fig. 30. Surface *a-a* with copper deposit. × 1.5. Fig. 31. Surface *b-b* with copper deposit. × 1.5

TABLE V—TRANSVERSE TESTS OF CARBON STEEL BARS FROM PARTY F

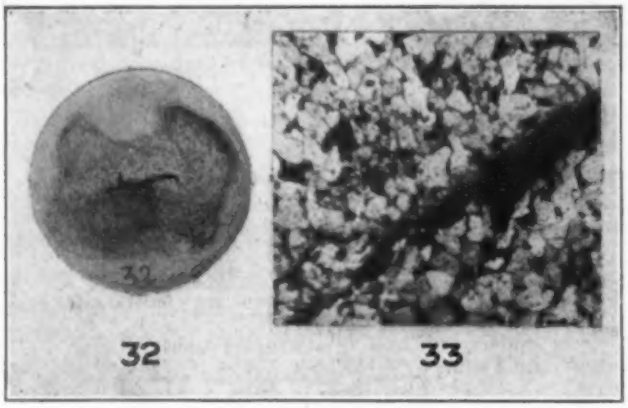
Test Bar Mark	Physical Properties				Analysis							Description of Fracture
	Elastic Limit	Ultimate Strength	Elongation	Reduction in Area	C	Mn	Si	S	P	Ni	Cr	
B1	42,430	71,900	23.5	46.3	0.25	....	....	.....	.....	....	....	Annealed. Scattered dots of greenish and dark slag.
A1	35,190	68,400	27.0	41.9	0.25	....	....	.....	.....	....	....	Annealed. Some small traces and dark dots.
B2	36,440	68,640	26.0	40.4	0.25	....	....	.....	.....	....	....	Annealed. A few small greenish inclusions in bright spots.
A2	44,930	68,640	21.5	27.5	0.25	....	....	.....	.....	....	....	Annealed. Many small yellowish and one very big brownish inclusion.
55 GA1	36,940	61,900	14.0	18.8								A mass of small yellowish green inclusions and many large brownish inclusions.
55 GB1	37,440	62,160	12.5	18.8	0.23	0.45	0.17	0.033	0.053	....	....	Same as 55 GA1.
55 AA1	41,930	60,400	21.0	29.9								Annealed. A mass of green slag inclusions.
55 AB1	26,960	60,660	19.0	29.5								Same as 55 AA1.
A 5050	51,420	87,120	13.0	20.6								Very many inclusions; small green; a few dark or light. Occur as streaks in laminated part and as dots and short streaks in crystalline part of fracture.
T 1-5050	51,920	82,880	23.0	37.7	0.38	0.56	0.20	0.028	0.045	....	....	Quenched at 1550, drawn at 1220. Several short shiny streaks and small traces.
T 2-5050	50,520	83,620	20.5	34.3								Quenched at 1550, drawn at 1220. Several small dark inclusions.
R1X	64,400	82,620	18.5	27.5	0.44	0.71	0.20	0.041	0.048	....	....	Quenched at 1550, drawn at 1250. Tenth of area is fibrous flake with several yellow inclusions. Balance crystalline with two or three slag particles.
R 2X	68,900	87,120	25.0	37.3								Some scattered traces.
R1Y	63,650	81,520	20.5	22.4								Quenched at 1550, drawn at 1250. Half area is fibrous flake with many greenish inclusions. None in crystalline part of fracture.
R 2Y	70,680	85,720	22.5	38.8	0.45	0.61	0.23	0.032	0.049	....	....	Some small greenish inclusions, several scattered small dark dots.

TABLE VI—LONGITUDINAL TESTS OF CARBON STEEL BARS FROM PARTY F

Test Bar Mark	Physical Properties				Analysis					Description of Fracture
	Elastic Limit	Ultimate Strength	Elongation	Reduction in Area	C	Mn	Si	S	P	
199 P	36,240	67,640	28.0	36.4	0.27	0.52	0.20	0.032	0.052	Annealed. A few light green inclusions in bright spots. Small dark spots scattered over surface.
202 P	36,840	69,050	27.5	33.5	0.26	0.48	0.20	0.033	0.047	Annealed. two or three round yellow inclusions. Small dark spots scattered over surface.
210 P	35,940	66,560	33.0	48.5	0.26	0.46	0.17	0.030	0.051	Annealed. Some large, round, yellow inclusions in bright spots and small holes between.
3872 F	51,580	73,980	0.0	0.0	0.45	0.76	0.23	0.032	0.048	Annealed. Irregularly cracked fracture with bluish dark inclusions along crack.
3872 FF	53,160	82,620	27.0	50.6						Small scattered holes and two or three small bright spots. No inclusions.
234I	36,420	67,060	10.5	19.9	0.28	0.42	0.14	0.036	0.054	Annealed. A smooth, velvety bright spot. Small scattered dark inclusions.
234II	33,220	64,660	12.5	32.0						A smooth, velvety bright spot.
3070 D	59,400	91,980	16.0	27.5	0.44	0.71	0.22	0.032	0.047	Water quenched and drawn. A spherical flaw, crystalline in center, dark irregularities on sides; perhaps dots of MnS.
M 53D	......	......	...	....	0.47	0.71	0.18	0.034	0.043	Heated in 11 hrs. to 1500; held 8 hrs.; heated in 2 hrs.; to 1600; held 2 hrs.; quenched in water; drawn to 1250 in 8 hr., held 6 hrs.; air cooled. Fracture showed angular flow, smooth and shining; probably side of an unwelded blowhole.

TABLE VII—CARBON STEEL BARS FROM PARTY G

Test Bar Mark	Physical Properties				Analysis					Description of Fracture
	Elastic Limit	Ultimate Strength	Elongation	Reduction in Area	C	Mn	Si	S	P	
1642-2	48,050	83,000	19.5	17.8	0.47	0.59	0.20	0.033	0.046	Whole fracture fibrous. Some dusty, thin, dark inclusions. Many traces.
1642-4	50,970	89,400	19.0	20.3						Whole fracture fibrous. Some thin dark streaks. Many traces.
2536-2	54,700	100,700	10.0	10.1						Three-fifths fracture fibrous with many shining dark slag streaks.
2536-3	53,280	96,140	10.0	10.0	0.50	0.55	0.26	0.052	0.035	Half fracture fibrous with many shining dark inclusions. A few small inclusions in crystalline part.
2536-4	55,260	101,900	12.0	13.4						Half fracture fibrous with many dark slag streaks.
2649-4	52,060	102,500	14.0	14.2	.....		.....	.....	.....	Half fracture fibrous with shining dark slag streaks.
2808-3	54,000	90,800	5.0	4.3	0.55	0.58	0.22	0.046	0.006	Third fracture fibrous with many dark shining slag streaks.
2856-2	50,330	93,760	20.5	25.9	0.46	0.68	0.24	0.037	0.039	Fracture irregularly fibrous, short dark streaky inclusions.
2856-3	50,880	96,700	17.5	28.9						Fracture irregularly fibrous, thin dark slag streaks.
2788-2	43,860	82,200	22.5	32.3						Fracture slightly fibrous. Some traces.
2788-3	44,230	85,000	19.5	24.9	0.55	0.58	0.22	0.050	0.036	Fracture fibrous. Some streaks of slag.
2788-4	49,060	87,400	17.5	26.2						Irregularly fibrous with small slag streaks.
2618-2	53,940	105,200	14.0	16.0	0.57	0.61	0.24	0.048	0.042	One-fifth fracture fibrous. Larger patches of shining slag.
2393-2	43,550	80,500	13.5	19.8						Laminated fracture. Large and small dusty steel gray inclusions.
2393-3	43,880	81,400	8.0	12.0	0.55	0.61	0.26	0.052	0.035	Half laminated fracture containing dusty steel gray inclusions.
2399-2	53,880	60,500	0.0	2.0						Bad fibrous flake. Irregular fracture.
2164-2	59,200	107,950	17.5	34.7						No lamination. Very short, dark traces at angle with fracture.
2154-3	63,050	107,700	7.0	6.3	0.52	0.52	0.22	0.047	0.034	One-tenth fibrous, filled with shining traces and dark slag streaks.
2164-43	62,050	105,400	7.0	8.4						One-fifth area at edge laminated, containing shining irregular traces and many thin dark inclusions.
2301-2	52,720	97,700	14.1	16.5						Half laminated. Traces, a dark slag streak, and some green inclusions.
2301-3	51,950	98,100	16.5	19.2	0.52	0.70	0.22	0.047	0.030	One-third fibrous. Shining traces and some tiny inclusions.
2301-4	53,200	100,950	17.0	26.8						Two-thirds fibrous. Shining traces and some slag streaks.

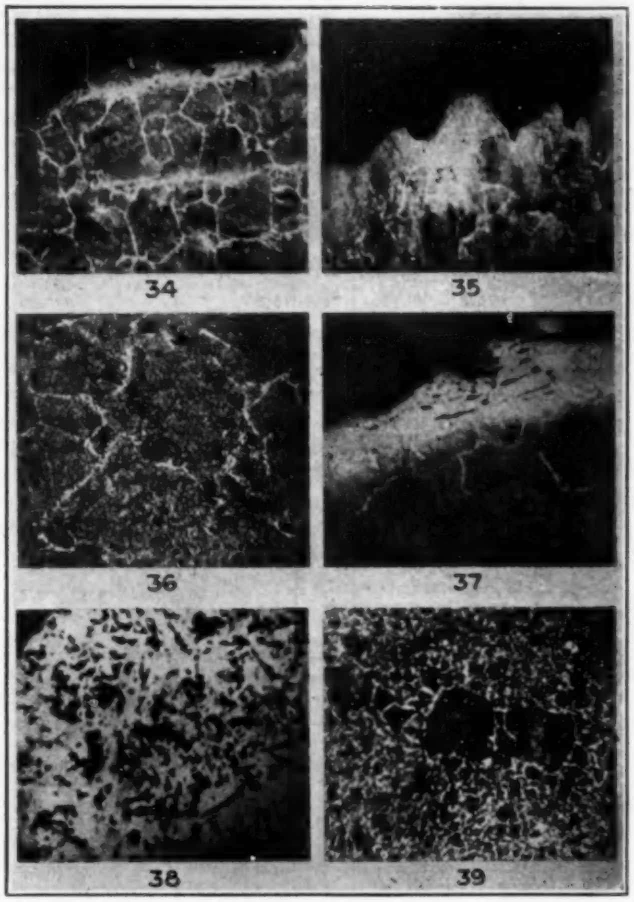


FIGS. 32 AND 33

Fig. 32. Improper forging opens internal cavity. Heyn's reagent. Natural size. Fig. 33. Same as Fig. 32. HNO_3 etching. × 100.

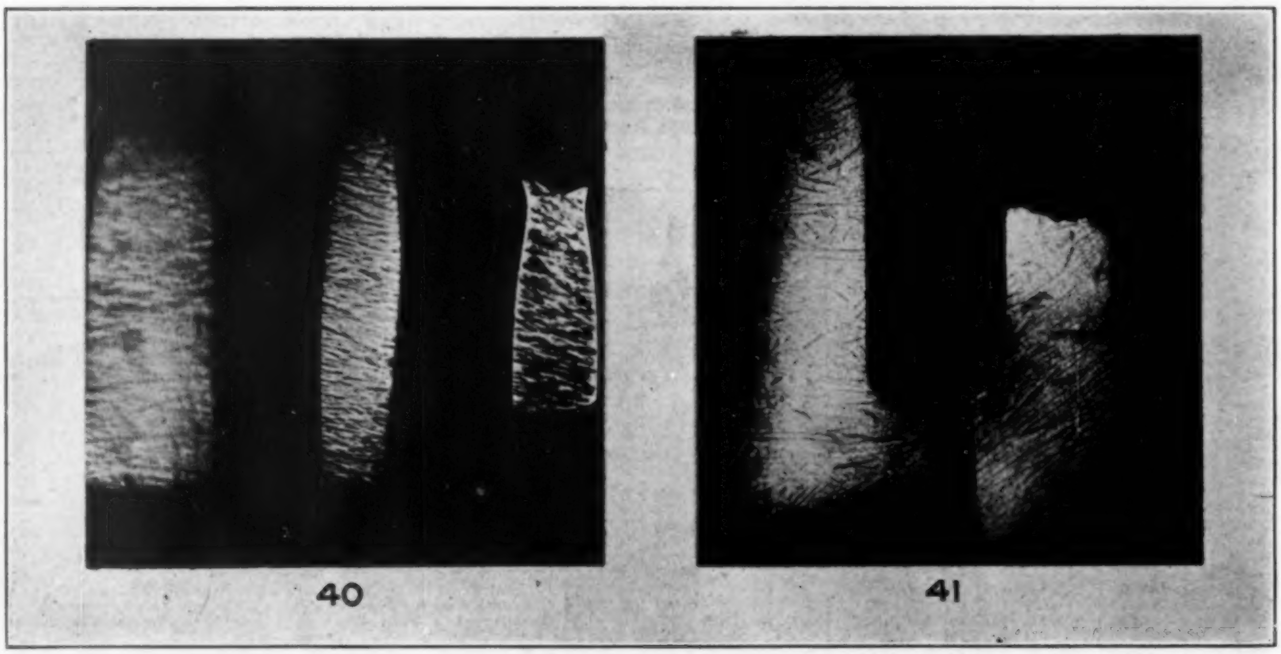
with large slag particles, but where possibly small dots of MnS are present. On cutting through this spot and examining the microstructure of the bright edge a somewhat heavier line of ferrite was found to accompany the fracture. Fig. 38 shows this structure a little back of the flake, giving the distribution of smaller grains within the larger primary crystal, which nearly outlines the picture and which is caused by heating to high temperatures.

Examination of transverse bars of higher carbon content from party G are given in Table VII. All the flakes here are of the fibrous type (Fig. 3). The slag inclusions—nearly all glossy, dark streaks—are almost exclusively in the fibrous part of the fracture. They are, as a rule, very thin, but where they are easily distinguishable the physical tests are lower. There is one peculiarity in these tests, namely, that in tests where only part of the fracture is fibrous, the elastic limit and tensile strength are higher, but the elongation and reduction in area are lower than in fractures where it is entirely fibrous, which may be explained



FIGS. 34 TO 39

Fig. 34. Transverse section of fibrous flake in sample A1 from party F. HNO_3 etching. × 50. Fig. 35. Longitudinal section of fibrous flake in sample A1 from party F. HNO_3 etching. × 50. Fig. 36. Section near spherical flaw shown in Fig. 7. HNO_3 etching. × 150. Fig. 37. Traces left after dissolution of MnS inclusions in decarbonized flake. Sample 3872, party F. HNO_3 etching. × 50. Fig. 38. Grain fragmentation in sample 234PI from party F. Iodine etching. × 40. Fig. 39. Phosphorus segregations in 2379 from party G. HNO_3 etching. × 50.



FIGS. 40 AND 41

Fig. 40. Split test bars, etched for dendritic markings. Natural size. Fig. 41. Accepted and defective test bars, split and etched for dendritic markings. × 1.5.

by a higher ductility of the fibrous than of the non-fibrous material. The fibrous part would yield earlier and act as a notch to fracture the rest of the bar. Sample 2379 from party G differs from the rest in that it shows phosphorus segregation with a large grain formation in a cut parallel to the fibers (Fig. 39), and these segregations can easily explain the presence of a fibrous fracture. There was also a noticeable difference in the tests of 2164 2, 3 and 4 which were taken out of the forging a couple of inches apart and parallel to one another. All had the same microstructure. Examination of the fractures showed a few small "traces"[5] in No. 2 apparently from slag protruding at an angle with the fracture; in 3 and 4, however, there were more particles which were parallel to the fracture. A section was cut through the bars parallel to the direction of forging and etched with Stead's reagent, with the result that 4 showed a much stronger phosphorus segregation than 2.

Dendritic Structure

This brought up the question whether the fibers were caused primarily by phosphorus segregation of the dendrites or whether slag streaks must be present for the formation of fibers. Several samples of cup fractures, one from party C with fibers and slag traces and two others from party B with cup fractures and no traces or fibers, were then cut parallel to the direction of work and the microstructure developed as shown in Fig. 40 (bar from C in middle). Where no slag streaks are present, fibers do not show up on pulling the bar transversely. Etching for transverse dendrites in laminated and cut fractures in Ni steel, from party A (Fig. 41), shows no difference.

Another possible cause for flake may be segregated spots such as are exhibited by the variable-hued grains in Fig. 23. Hard spots are very often found in steel and are mostly phosphorus segregations, or they may be caused by incomplete solution of ferromanganese[6].

Summary

From the foregoing the author has endeavored to show that the predominant cause for flakes is slag inclusions. They may less often be caused by cracks formed by faulty mill practice, by blowholes or segregations. No distinct microstructure is found associated with flakes; therefore in general heat treatment is powerless to cure them.

In a subsequent communication the correct furnace practice to follow to reduce slag inclusions to a minimum will be discussed, which procedure has in practice largely reduced the rejections in plants which have adopted it.

Carnegie Institute of Technology,
Pittsburgh, Pa.

[5]As previously noted, "traces" are shiny smooth spots from which slag particles have fallen.
[6]Harden, Metallurgical & Chemical Engineering, 1917, p. 702.

Melting Points of Chemical Elements, and Other Standard Temperatures

THE following table of melting points of the chemical elements is issued by the Bureau of Standards in answer to numerous requests for this information:

The values of the melting points used by the Bureau as standard temperatures for the calibration of thermometers and pyrometers are indicated in capitals. The other values have been assigned after a careful survey of all the available data.

As nearly as may be, all values, in particular the standard points, have been reduced to a common scale, the thermodynamic scale. For high temperatures, and for use with optical pyrometers, this scale is satisfied very exactly by taking $c_2 = 14\,350$ in the formula for Wien's law connecting $I\lambda$ monochromatic luminous intensity of wave length λ, and T, absolute temperature: $I_\lambda = c_1\lambda^{-5}e^{-\frac{c_2}{\lambda T}}$. For all purposes, except the most accurate investigations, the thermodynamic scale is identical with any of the gas scales.

At high temperatures some of the values are quite uncertain; thus, while the melting point of platinum may be considered accurately known to 10 deg. C., that of tungsten is possibly uncertain by 50 deg. C. or more. Temperatures Centigrade are rounded off, and the exact Fahrenheit equivalents are usually given.

MELTING POINTS OF THE CHEMICAL ELEMENTS

Element	C	F	Element	C	F
Helium	<—271	<—456	Arsenic	850	1562
Hydrogen	—259	—434	Barium	850	1562
Neon	—253?	—423	Praseodymium	940	1724
Fluorine	—223	—369	Germanium	958	1756
Oxygen	—218	—360	SILVER	960.5	1760.9
Nitrogen	—210	—346	GOLD	1063.0	1945.5
Argon	—188	—306	COPPER	1083.0	1981.4
Krypton	—169	—272	Manganese	1230	2246
Xenon	—140	—220	Beryllium (Glucinum)	1280	2336
Chlorine	—101.5	—150.7	Samarium	1300–1400	2370–2550
MERCURY	— 38.87	— 37.97	Scandium	?	....
Bromine	— 7.3	+ 18.9	Silicon	1420	2588
Caesium	+26	79	NICKEL	1452	2646
Gallium	30	86	Cobalt	1480	2696
Rubidium	38	100	Yttrium	1490	2714
Phosphorus	44	111	IRON	1530	2786
Potassium	62.3	144.1	PALLADIUM	1549	2820
Sodium	97.5	207.5	Chromium	1615	2939
Iodine	113.5	236.3	Zirconium	1700?	3090
Sulphur	S_I 112.8	235.0	Columbium (Niobium)	1700?	3090
	S_{II} 119.2	246.6	Thorium	>1700? <Mo.	>3090 <Mo.
	S_{III} 106.8	224.2	Vanadium	1720	3128
Indium	155	311	PLATINUM	1755	3191
Lithium	186	367	Ytterbium	?	....
Selenium	217–220	423–428	Titanium	1800	3272
TIN	231.9	449.4	Uranium	<1850	<3360
Bismuth	271	520	Rhodium	1950	3542
Thallium	302	576	Boron	2200–2500?	4000–4500
CADMIUM	320.9	609.6	Iridium	2350?	4260
LEAD	327.4	621.3	Ruthenium	2450?	4440
ZINC	419.4	786.9	Molybdenum	2550	4620
Tellurium	452	846	Osmium	2700?	4890
ANTIMONY	630.0	1166.0	Tantalum	2900	5250
Cerium	640	1184	TUNGSTEN	3400	6152
Magnesium	651	1204	Carbon	>3600	>6500
ALUMINIUM	658.7	1217.7			
Radium	700	1292			
Calcium	810	1490			
Lanthanum	810?	1490			
Strontium	>Ca<Ba?	....			
Neodymium	840?	1544			

OTHER STANDARD TEMPERATURES

Substance	Phenomenon	C	F	Variation with Pressure (Pressure in mm. of Hg)
OXYGEN	Boiling	—183.0	—297.4	$C° = -183.0 + 0.01258\,(p-760) - 0.0000079\,(p-760)^2$
CARBON DIOXIDE	Sublimation	— 78.5	—109.3	$C° = -78.5 + 0.01595\,(p-760) - 0.0000111\,(p-760)^2$
SODIUM SULPHATE $Na_2SO_4 + 10H_2O$	Transformation into anhydrous salt	32.384	90.291	
WATER	Boiling	100	212	$C° = 100 + 0.03670\,(p-760) - 0.00002046\,(p-760)^2$
NAPHTHALENE	Boiling	217.96	424.33	$C° = 217.96 + 0.058\,(p-760)$
BENZOPHENONE	Boiling	305.9	582.6	$C° = 305.9 + 0.063\,(p-760)$
SULPHUR	Boiling	444.6	832.3	$C° = 444.6 + 0.0908\,(p-760) - 0.000047\,(p-760)^2$
3Ag2Cu	Eutectic freezing	779	1434	
SODIUM CHLORIDE	Freezing	801	1474	

Solid Rubber Tires

History of Solid Rubber Tire Development, Sidewire and Wired-on Types—Bands—Hard Rubber Base, Methods of Applying and Quality of Stock—Calendered and Tubed Treads, Manufacturing Processes and Comparison of Tires—Testing of Solid Tires, Specifications

BY ANDREW H. KING

THE USE of solid rubber tires depends on two main characteristics. First and foremost, they tend to equalize road surfaces, protecting both vehicle and rider from shock. In this a solid tire is very inferior to the pneumatic. Rubber cannot be compressed. It can only be deformed and to an extent dependent on the degree of loading of the stock. Solid tires are heavily loaded. By this I mean that more than 30 per cent of the volume of the tire is something other than rubber. In present practice zinc oxide, or lampblack, or both are chiefly used. The normal elasticity of rubber is greatly reduced. On the other hand a pneumatic tire depends on rubber and fabric only to provide the container for the true carrier, which is air under pressure. In common with other gases it is approximately perfectly elastic. It can be compressed at will. For this reason it provides the ideal cushion. However, solid tires are unquestionably greatly superior to a steel band, and their introduction during the early '80s for carriages was indeed a great step.

The second function did not develop until after motor-driven vehicles were introduced, when they were required to provide traction. This brought about a widening of the tire and a decrease in its diameter. From this standpoint the solid tire is satisfactory as long as it is kept on good roads. It is useless in mud, or on wet, slippery asphalt paving.

SOLID VS. PNEUMATIC TIRES

As is well known, the solid rubber tire was first introduced for carriages. Then followed the advent of the automobile with its greater speed, when the pneumatic tire largely replaced it for pleasure vehicles. But the development of the motor truck has given it a new lease on life. Here pneumatics in large size were until the past year or so unavailable. Even yet they are more expensive, liable to puncture, and not wholly satisfactory. The solid tire is dependable, it lasts a long time, and can carry a high overload for a short distance without danger. One prominent exponent of pneumatic truck tires is confident that history will repeat itself and that the solid truck tire will eventually give way to the pneumatic. Perhaps he is right, but for some years to come the manufacture of solid tires will continue.

There is no great certainty as to when solid rubber tires were first introduced, but we do know that their use was nowhere general until they were applied to the extensive line of hansom cabs operated in London in the early '80s by the Shewsbury & Talbot Noiseless Tire & Cab Co. Their tire had been invented by Carmont, whose patents were granted in 1881 and 1883. By the original definition, it was a rubber tire held in a rolled steel channel in a state of compression between converging flanges.

FASTENING TO THE WHEEL A PROBLEM

It is well to digress at this point and to note that the great difficulty in tire design was not to provide a stock which would stand up well under the conditions of service, but the problem was how to fasten such a tire to the wheel. For Carmont's purposes compression in a steel channel was sufficient. But by so doing he decreased the readiness with which his tire was deformed. It was hard, and except for being noiseless was little better than the steel band.

The logical advance from this stage was, of course, to the "wired-on" type. Grant[1] held his tire in place by means of longitudinal wires, two at first and more for larger sizes. His channels were not as deep as those of Carmont. More rubber was exposed for wear, and as there was no compression the tire had greater resiliency.

The Burgess tire was similar to the Carmont except that he introduced longitudinal wires which had been wrapped with small special wires for the protection of the rubber. The Victor tire was similar to Grant's, but the wires were encased in leather.

MANY TYPES DESIGNED

Easier of application, but similar in principle, was the "sidewire type," known also as the Firestone and as the Swinehart & Byrider[2], who were the patentees. It was held in place by two endless retaining wires which were sprung over the edges of the channel and engaged the ends of embedded cross wires or bars. In this way the tire was held securely in place.

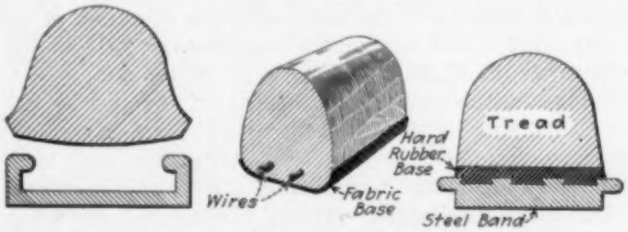
The various "wired-on" types are reasonably satisfactory in sizes up to 2¾ in. in width; i.e., for buggies, carriages, victorias, etc., where the tire is not required to transmit traction. In larger sizes and where "traction" must be furnished, the strain on the stock next the retaining wires causes tearing, which ultimately throws the tire. This difficulty led to the development of many very ingenious designs. The splice which proved such a difficulty in the "wired-on" type was eliminated. The new tire was endless, i.e., spliced, and fastened in the uncured condition to a special band which was so designed as to be easily mounted on the wheel, usually by removing a flange which when bolted in place held the tire securely.

No mechanical method of fastening the tire to the band proved satisfactory. Wires, steel rods, bands, etc., no matter how complicated, all cut or tore the tire when

[1]U. S. Pat. 554,675, 1896.
[2]U. S. Pat. 686,556, 1901.

placed under strain. The solution of the problem was very simple, and was developed in Germany by the Metzler Co. They dispensed with all wires, hooks, etc., and interposed between the steel band and the tire a hard rubber base which securely united them. To strengthen the union to the band they introduced an ingenious system of dovetailing. In this way no local strain was placed on the tire, the load being taken uniformly by the whole base of the tread. This type of tire has now come to be accepted as the standard form.

There are two ways of fastening such a tire to the wheel. For the smaller sizes (3 to 5 in. in width) bolts and flanges are satisfactory. For larger widths the traction is too great and a larger number of bolts are necessary for secure fastening. To combat this



FIGS. 1, 2 AND 3. ON LEFT, SECTION OF CARMONT'S TIRE. IN CENTER, GRANT'S TIRE—STANDARD AMERICAN CARRIAGE TIRE. ON RIGHT, METZLER'S TIRE

trouble the "pressed-on" type was developed. The band is forced on the wheel by hydraulic pressure. It is placed under considerable tension, which effectually prevents any creeping of the tire on the wheel. At the present writing very few bolted-on tires are made. The pressed-on tire with a hard rubber base is apparently the last word in solid tire design.

Solid tires may be classified in three broad divisions, namely, carriage, truck and cushion. The essential details of manufacture are outlined below.

Carriage Tires

The chief demand for rubber tired carriages is found today in certain parts of the South, Canada and South America, regions where the "flivver" is as yet unknown or impossible because of bad roads.

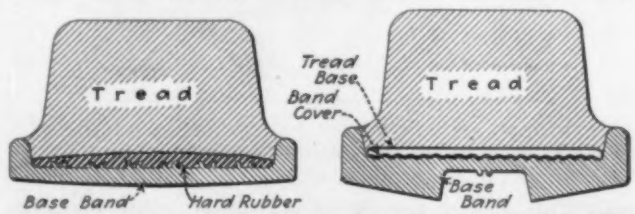
Carriage tires are shipped to the various wagon shops in reels of variable lengths and in widths running from $\frac{1}{2}$ to $2\frac{3}{4}$ in., depending considerably on the purpose for which the tire is intended. Under this head is included the cheap grade which is made in small sizes for invalid chairs, etc.

Stock: The compound employed will vary with the severity of the service. The chief considerations are price, specific gravity, body, strength, easy working, a certain degree of hardness, and a reasonable "give." To keep the cost down very little rubber is used. Shoddies are quite satisfactory. The "body," or, expressed differently, the degree of loading, is very important. To tube nicely the stock must be firm but not too soft and never very sticky. The proper balance of these qualities is unfortunately only learned by experience, and is almost impossible to describe. The curing agents must be carefully chosen. The accelerator must not be high powered or it will be liable to cure the stock in the tube machine. A common fault with many carriage tires is slight blowing which is indicative of an unbalanced formula or an insufficient quantity of stock in the mold, thus preventing proper pressure on the tire during curing.

Milling and Warming Up: Many carriage tire formulas give a batch which is difficult to handle on the mills. There is little if any rubber to hold it together and frequently asphaltic or other sticky material will be present in quantity. For the poorer grades a scraper attachment is absolutely necessary, as the stock cannot be batched off by the mill man. The scraper is a knife 6 to 8 in. wide fastened to the end of a lever, the fulcrum of which can be slid back and forth in a direction parallel to the length of the rolls. When the batch leaves the mills it is in ideal state for tubing. It is soft, plastic, and will take almost any shape imposed. But no tube machine can be operated efficiently without a supply of stock on hand. Therefore it is necessary to install a warming up mill in close proximity to the tube machine.

The Tube Machine

Tubing: The tube machine is designed and operated on the same principle as the old-fashioned sausage grinder and stuffer. Pieces of warmed stock, cut to convenient size, are fed by hand. A worm which operates in a casing carries it forward, packing the stock tightly together all the while. At the end of the worm it enters a sleeve which reduces it in diameter, and then passes through a die. Except for being power driven and stronger and heavier it is exactly like a sausage machine. Since shoddies frequently contain pieces of metal, a wire screen is sometimes placed in the sleeve to intercept them. The internal wire holes of the "wired on" tires are made by attaching to either the die or the carrier two metal forks which project through the opening. As the stock passes beyond the die the compression is removed and the holes remain intact. Considerable experience is required in adjusting the temperature of the die, which is regulated by a skilled operator with an ordinary bunsen burner. As all stocks do not tube well at the same temperature,



FIGS. 4 AND 5. SECTIONS OF STANDARD SOLID TIRES. ON LEFT, "PRESSED-ON" TYPE, ONE HARD RUBBER. ON RIGHT, "BOLTED-ON" TYPE, TWO HARD RUBBERS

no little experimenting is required before the best conditions are arrived at. The casing is jacketed and is provided with means for heating and cooling similar to the ordinary mill. As the tire leaves the tube machine it passes first through powdered soapstone and then through revolving brushes which remove the excess. At this point it is picked up by a conveyor belt traveling at slow speed. When the desired length is attained, which depends solely on the length of the heaters, the operator cuts it off and throws it into a tray, after which soapstone is blown through the wire holes.

Cheap tires, such as the poorer grades of baby carriage tires, are not handled quite in this manner. As

the tire comes from the tube machine it is coiled up on a circular rotating board. When the board is full the tires are dusted with soapstone. Such tires are not infrequently given an "open steam" cure. The board is covered with a layer of soapstone an inch or more in depth and put directly in the heater without any wrapping whatever. The procedure is not very satisfactory, but is sufficient for the quality of goods produced.

Wiring: Wires of the proper size are inserted in the holes in rather a clever manner. The nozzle of a compressed air line is pressed tightly against the holes at the opposite end from which the wires are to be inserted. The holes are slightly distended when the wires are started through, thus allowing them to slide in on a cushion of air.

Curing: Only a small portion of the annual carriage tire production is cured under hydraulic pressure. Usually full dependence is placed on a series of bolts which are tightened down by the heater men. The heaters are quite long, varying from 20 to 50 ft. in length, and consist essentially of two steam heated platens. The steel molds are detachable, so that the same heater may be used for curing tires of various widths. At each end of the platen are spaces a foot or more in length, which are spoken of as "dead" or "cold" ends. As will be seen later, they are very convenient in splicing the successive lengths into a long reel.

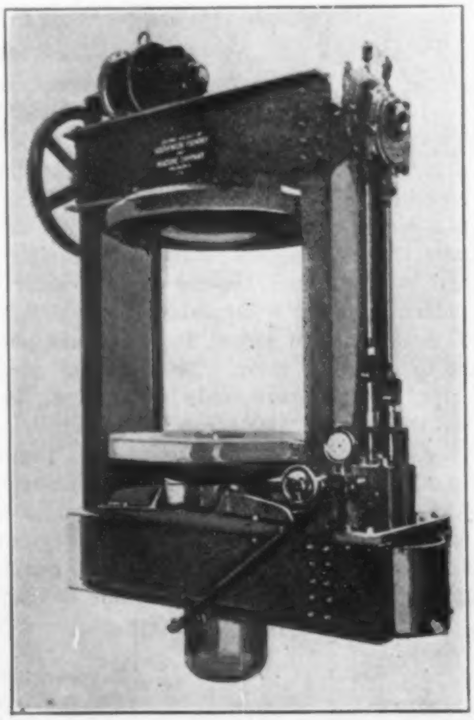


FIG. 6. 200-TON PRESS FOR FORCING SOLID TIRES ON OR OFF WHEELS

The Usual Curing Procedure

The usual curing procedure is as follows: The wired lengths are placed in the mold face down. The bases are scrubbed with gasoline to remove the soapstone, then given a coat of cement, and the tape, frictioned on one side, is applied. The fabric backing gives the tire a longer life. This length is spliced to the preceding one as follows: It projects, let us say, one foot into the left "dead end," which brings it a foot from the right "dead end," on which side the reel is located. The uncured end of the previous length is hauled down, the ends of both tires cemented and joined together. The tape is carried six inches or a foot beyond the splice. This leaves a section of the cured portion in the right "dead end." Some presses are designed with only the left "dead end," but they are not quite as satisfactory as those described above. The top platen, which is raised and lowered by a chain block, usually electrically driven, is set in place and bolted down.

When the period of vulcanization is completed the first step is to remove the wires, which is sometimes very difficult. The operator grasps the end of the wire with a special set of forceps which are designed so as to give him a firm hold and a long leverage. He twists and turns the wire until it is loose in its cavity. By applying compressed air at the end of the reel as before, the wire is drawn out without further trouble. Wires which have been in constant use for some time require an occasional bath in caustic soda to clean them.

The tire is trimmed by passing between two revolving knives, which remove the "rind." The lengths are measured, weighed, and wound on reels, when they are ready for shipment.

Applying Tire to Wheel

Application: The method of applying such a tire to the wheel is interesting. Special apparatus, of which there are numerous designs, is required. Three things must be done simultaneously. The wheel must be firmly held so as not to rotate, the wires must be placed under tension, and the tire itself must be compressed, i.e., slid back from the splice a distance of at least eight inches. Then the wires are brazed together. The ends of the tire are cleaned with solvent, given a coat of cement, and acid cured by brushing a little sulphur chloride solution over the cemented ends and bringing them quickly together.

Carriage tires must stand up on all kinds of rocky, muddy and sandy roads. They must have great resistance to abrasion and must age well. The old carriage tire man put a suitable product on the market long before the era of testing machines. He depended upon a few simple tests which are worthy of brief mention.

Slice Tests: By snapping a thin slice cut perpendicular to base of the tire but not quite to the wire holes one is able to judge very closely as to the spring, elasticity and cure of the tire. The force required to pull this piece off gives a measure of the tensile strength of the stock.

Tread tearing: The face of the tire is cut back at a small angle so as to give a hand hold. Pressure is then applied to separate tread from base. The force required furnishes an index as to the wearing value of the compound.

Twisting: One should be able to twist a good tire a number of times, and find on releasing that it regains almost completely its original shape. Many cheap tires are so loaded with asphaltic material that they appear dead and lifeless. They do not even approach their original shape.

Bending: The surface of the tire should show no

checking or cracking when bent through 180 deg. and the surface scratched with the back of a knife or the finger nail.

Hardness: If the point of a pencil is pressed straight down into the tire the pressure required is an index of the hardness, and the rate of recovery shows the nature of the stock.

The tensile strength of carriage tire stocks usually varies from 700 to 1200 lb. per sq.in. The stretch runs from 200 to 350 per cent. The set (Bureau of Standards method) is from 15 to 35 per cent.

The life of a good tire is very long. This is partly due to the intermittent service it receives, and partly to the light loads carried.

Truck Tires

As indicated above, practically all truck tires are built on steel bands which are either bolted on or pressed on to the wheel. Pressed-on tires make up a very high percentage of the total output. Except for slight variation in the design of the band, there is no difference between the two types, and they will be considered together without further mention. The essential parts of the tire are: The band, hard rubber base, and the tread. They will be considered in order.

Bands: They are of mild steel corrugated and rolled to the desired width and design at the mill, and are usually delivered to the manufacturer in long lengths. He then bends them to the desired diameter and welds the splice, usually with electric welders. Before the bands are ready for covering they must be sand-blasted to remove any rust. Blasting also slightly roughens the surface, which causes the band cover to stick much better.

Hard Rubber Base: This is beyond question the critical part of the tire, and that on which its success is largely dependent. Several manufacturers have recently learned to their sorrow that poor hard rubber ruins a tire. If it does not cure up properly, or if it does not stick well to both band and tread, they will separate. This is the end of the tire regardless of how good the tread may be. Union to either band or tread is fairly easy, but to both is quite difficult. The presence of corrugations and uneven grooves in the band allow a softer hard rubber to be used as they increase the union. This is perhaps the poorest solution to the problem, but many good tires are made after this fashion.

One or two makers of tires do not depend on just one hard rubber. They use two. The band cover, i.e., the one in contact with the band, is completely cured up and sticks to it very well. On top of this is the tread base, which is a semi-hard rubber. It sticks well to both band cover and tread.

Applying the Band Cover

This is perhaps the best scheme, though it must be more expensive. In either case the first step is to apply the band cover. The sand-blasted band is placed on a revolving spider or chuck. A number of spiders are mounted in a long row. Each one is belt-driven from a shaft overhead, but is fitted with a clutch so that it may be started and stopped at will. The band surface is cleaned first with wire brushes to remove any sand or scale and then with gasoline or benzol to remove any grease. The solvent used must be free from grease and sufficiently volatile so that none remains a few minutes after washing. The green stock is milled, calendered, and cut into proper width and length in the usual manner. The end of strip is pressed down on the band with care that it is in proper alignment. The band is started slowly and the stock pressed down with a wide flat roller. Then the speed is increased and a narrow stitcher is used. This presses the stock tightly into the grooves. Where any individual design is to be given to the hard rubber a special roller is used to finish it. Next the surface is washed well with solvent

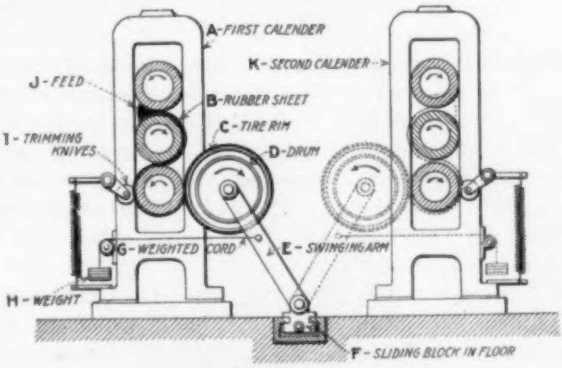


FIG. 7. GRAY'S APPARATUS FOR CALENDERING SOLID TIRES

and allowed to dry. If there is only one hard rubber to be used, the band is now ready for the tread. Tread base procedure will be described later.

Tread: Formerly most treads were made up of two or even three different types of stock. But this has now been practically abandoned and only one kind is used for the tread. There are two general methods by which the tread is prepared, i.e., calendering and tubing. The former will be considered first.

Calendered Tread

The steps here are as follows:

Filling the Band: The covered band (i.e., covered with hard rubber) must be filled with tread stock to a little past the edges of the channel. Filling is usually done by hand, using strips of calendered stock.

Treading: The filled band is placed on a special apparatus for holding it against the lower roll of the calender. Two designs are indicated in the accompanying sketches. Fig. 7 is representative of old practice when more than one tread stock was used. The tire is built to a certain thickness on one calender and is then thrown over to the other calender, where the second tread is applied. This design is weak in that the pressure under which the stock winds up is not very great. Present practice is better. The tire is mounted on a chuck which is carried by the piston rod of a compressed air cylinder. With this apparatus the tire is built up under pressure. The plies stick together better and the tire lasts longer in service. When one tire is completed the apparatus is rotated. This brings another band into position.

Trimming: When the tire leaves the calender it is rectangular. It must be trimmed to the section of a trapezoid and if the size is 10 in. or over it must be grooved according to best practice. This is accomplished by placing it on a revolving chuck, rotating it at high speed and advancing a knife in a manner similar to the

handling of the cutting tool on a lathe. The grooving is done with a special spoon shaped knife.

Several manufacturers use the calender process for tires 10 in. or more in width, and many others make all sizes from 7 in. up in this way. For sizes in excess of 7 in. a very large tube machine is required, and the difficulties incident to handling so much stock efficiently are not small. There is said to be but little difference in cost between tubed and calendered tires, though the writer believes the latter has a shade the edge on the former.

Tubed Tread

The stock is prepared in the usual manner. It is customary to use two or even three warming up mills to keep the tube machine well supplied. It is similar in design to the one described under carriage tires, but is many times larger and stronger. The die gives the tire its approximate shape. There are two general procedures for handling such tires, known as the hot and cold methods respectively.

Hot Method: The tire as it comes from the machine is applied directly to the covered band, which has been placed on a revolving chuck close by. The proper length is cut off and the splice made with the hot stock. It

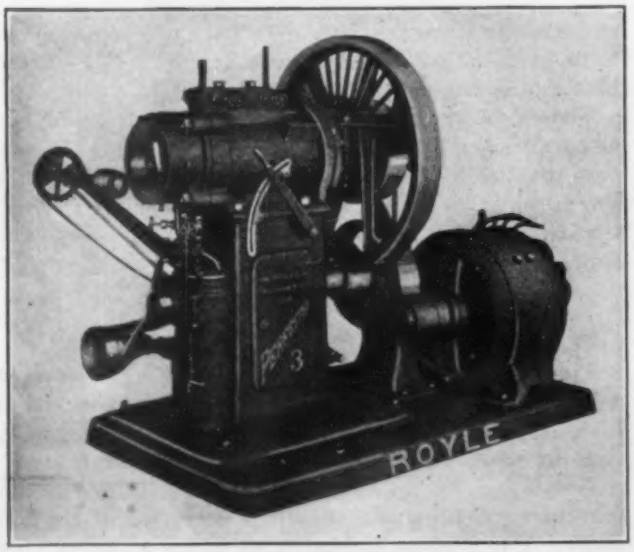


FIG. 8. TUBE MACHINE, SIZE SUITABLE FOR CARRIAGE TIRES

then goes to the power stitcher, where the thread is forced in close union with the hard rubber base. The power stitchers are two fair sized rollers, power operated. The lower roller supports the band and the top one is lowered by means of a screw so as to bring pressure to bear on the thread. After trimming off any stock which has been forced out the tire is ready for curing.

The hot method is quick, cheap and very efficient; but does not give entirely satisfactory unions, due perhaps to a semi-curing of the hard rubber.

Cold Method: Formerly all tires were tubes in single stick lengths just the same as carriage tires. But now several factories run a double stick and saw the two halves apart. This practice is, of course, impossible when tires are handled by the hot method, but for the one being described it is very appropriate. It is cheap, efficient, and produces a better tire.

Process by Cold Method

The double stick is picked up by a slow moving conveyor belt as it leaves the tube machine. When the proper length is reached it is cut off, rolled over on a board, weighed, and allowed to cool. When the stock shows a tendency to swell unevenly on cooling, it is often necessary to drop the stick into steel forms, where it remains until quite cold.

Sawing: The stick is cut into two treads by a rapidly moving band saw, the blade of which has very small teeth or none at all. A special feeding device is employed to hold the parts firmly and at the same time keep them separated. The design ordinarily used is a combination of a conveyor belt with a number of grooved rollers.

Tread Base: Where only one hard rubber is used, the tread goes direct to the building room, where it is spliced and placed on the band. Because of the value of the two-hard-rubber tire, we will take up now the tread base. As above mentioned, it is a semi-hard rubber designed to unite the tread and band cover. Milling and calendering of the stock is according to usual practice. It arrives in the applying room wound up in narrow reels.

The sawed treads are placed on a rack face down. The bases are washed well with either gasoline or benzol and allowed to dry in an atmosphere free from dust. When dry they are loaded on a conveyor, which delivers them to the rolling machine. This is a simple contrivance which increases the efficiency of the application. The reel of tread base is hung overhead and unwrapped as needed. When the conveyor delivers a fresh tread, the machine is stopped and the tread base firmly attached for about an inch, after which the work proceeds. The tread and base pass under a wide roller, which presses them firmly together, thus producing a very good union. As the tread comes out on the other side of the roller the edges are trimmed, usually with a V-shaped knife whose inner edges are sharpened. The stick is cut to proper length and receives its final weighing. The upper surface of the tread base requires washing to remove dust. Sometimes a coat of cement is necessary. When the stocks are dry and do not unite easily, it is usual practice to cement both tread and hard rubber regardless as to whether one or two stocks are in use.

Splicing Methods

Splice: There are two methods of cutting the stick for splicing. In some factories the cut is made square. This is known as a butt splice. The other and most usual form is the diagonal splice. The stock is cut at a 45 deg. angle so as to give longer joining surface.

The cut ends are washed with solvent, dried, and placed in the jammer. It consists of two clamps having wide knurled faces. One clamp is fixed, but the other is movable. Considerable force is applied by means of a fairly long lever, thus effectually pressing the ends together. The stock is held under pressure only a minute or so. The method is very good. The joint is stronger than the green stock anywhere else in the tire.

Application to Band: The tread is now a ring. The

band is placed on a circular table, which may be rotated. The ring is stretched and fitted over the band by means of rubber mallets and a set of three or more irons which are similar in shape to carpenters' wood chisels. Then the edges are stitched under the sides of the band with narrow steel stitchers. From the applying table the tire goes to the power stitcher, where the tread and hard rubber are pressed tightly together.

Curing

In the foregoing we have covered the principal variations in the preparation of "pressed-on" or "bolted-on" truck tires, bringing them all to the state when they are ready for curing.

All truck tires are cured in autoclave presses in heavy sectional cast iron molds. The heaters are set so that their upper edge is about 2 ft. above the floor of the pit, which is the name applied to the curing room. They are massively built. From twenty to thirty tires can be cured at one heat. This type of heater combines the advantages of press and open steam cure. The molds and tires are accurately heated throughout and the desired hydraulic pressure is applied at the same time. The lid of the heater is secured by bolts or by a system of slots. The latter form is now most in use. The lid drops in place and is locked by turning it a distance of about six inches. It serves as a backstop for the hydraulic ram, which is placed in the bottom of the heater. Pressure is transmitted through the molds to the lid.

Because of the extreme thickness of the stock to be vulcanized, a rising cure is absolutely necessary. The first stage is of short duration and low temperature. The second and third are progressively longer and at higher temperatures. Three raises are usually sufficient, but some of the very large truck tires require four. When the period is ended the steam and hydraulic are shut off, the heater drained, and the lid removed. Then it is filled with cold water to cool the molds sufficiently for handling. When cool, water pressure is applied to the ram and the load gradually raised. The molds are opened with bars and the parts carried off by chain blocks which run on an overhead trolley.

The tires are removed, trimmed and inspected. They are then ready for sale.

Comparison of Tubed and Calendered Tires

In a calendered tire the plies are wound up spirally. The grain is therefore circumferential. Maximum strength is in this direction. The tire is weakest across the grain. Tearing takes place with the grain, i.e., parallel to the circumference. The bond between the plies is comparatively weak. When a calendered tire fails in service it is usually because of ply separation or tearing with the grain.

When a tire is tubed in a single stick, the grain runs in concentric cones along an imaginary line through its center parallel to its length. Such tires develop in service peculiar looking tears and cuts, which of course follow the lines of the grain. When the tire is tubed in the double stick, the grain is in the same direction, but the ends are tied down to the hard rubber base, thus presenting a fairly uniform resistance to cutting, etc. However, when the stock is not of quite the right texture due to stiff crude rubbers, or for any reason such as when it does not receive proper compression in the tube machine, there is a distinct line of weakness along the grain and the tires develop herringbone breaks after a short time in service.

It is still an open question as to which is the better, calendered or tubed tires. The main objection to calendered tires is ply separation, and to tubed tires herringbone breaks.

Testing of Solid Tires

Notwithstanding the action of the Government in discontinuing the Barbecue test, the writer feels that this is the best way to obtain an accurate knowledge of the state of things within the tire.

Barbecue Test: The tire is placed in a vise and securely fastened. By means of a knife a long, slanting cut is made in such a way as to separate about 18 in. of tread. Around this a rope is looped, which is in turn

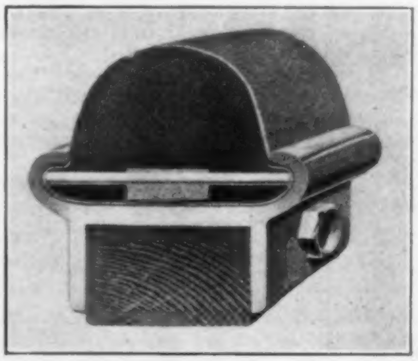


FIG. 9. SOFT-BASE TRUCK TIRE

fastened to a steel cable connected through a dynamometer to a chain block. A little tension is applied and the tread cut through, down to the hard rubber. Load is gradually increased and the trend union determined by the pounds pull required to separate it from the hard rubber. Former Government specifications required at least 100 lb. per inch of width. Thus a 6-in. tire was required to show a tread union of 600 lb. or more. As a matter of fact, the better grades of truck tires run much above this. Some go as high as 200 or even 300 lb. per inch of width.

The union of the hard rubber to the band is examined with a hammer and chisel. It should be so good that one can separate a piece of hard rubber within itself easier than it can be removed from the band. Where two hard rubbers are used, they should adhere so tightly that they cannot be separated. A section of tread is cut off squarely and placed in a slicing machine. It is similar in design to those used in butcher shops for slicing bacon, etc., but is much heavier and has a power drive. Both longitudinal and transverse sections are cut. Transverse slices are tested by the compounder for cure and feel. Regular tests for tensile strength, etc., are made on the others.

In view of Government specifications covering solid rubber tires the tendency has been for all makers to bring their product somewhere near the quality required. Therefore the following abstract of specification No. 1074-A may be taken as descriptive of American truck tire practice to-day.

1. *Rubber:* The compound shall contain not less than 65 per cent by volume best quality wild or plantation rubber. Shoddy or mineral rubber when used is to be in addition to this 65 per cent. Refined or ground vulcanized rubber is barred.

2. *Sulphur:* Not more than 8 per cent on the weight of crude rubber employed. This figure is plenty high.

3. *Saponifiable Matter:* Saponifiable oils or anything made from them are barred. This eliminates rubber substitutes.

4. *Tensile Strength:* They divide tires into two classes. (*a*) Those where the specific gravity is 1.40 or over (high zinc oxide) shall have a minimum tensile of 1800 lb. per sq.in. (*b*) Those having a specific gravity of under 1.40 (high lampblack) must have a minimum tensile of 2000 lb. per sq.in.

5. *Stretch:* Standard is placed at 350 per cent.

6. *Set:* Not over 40 per cent two minutes after rupture is maximum.

7. *Aging:* After heating two hours in an oven at 228 deg. F. the depreciation when tested 24 hr. later is to be not more than 35 per cent in elongation.

8. *Adhesion:* The tire is placed horizontally on the platen of a tire applying press, supporting it on a steel band having the same diameter as the base of the tire to be tested. On the upper side a band ½ in. thick with an inside diameter 1½ in. larger than the outside diameter of flange of base band is applied. The corners of this band are rounded with ¼ in. radius. The various sizes of tires are to be submitted respectively to pressures in accordance with the following table. For the tire to pass successfully the hard rubber must not break loose from the base.

9. *Life:* A minimum life of 7000 miles per tire must be assured.

Sise of Tire	In. Diam. of Press Ring	Lb. per Lineal Inch	Pressure in Tons on Tire, Max.	Size of Tire	In. Diam. of Press Ring	Lb. per Lineal Inch	Pressure in Tons on Tire, Max.
32x3	29	175	8	32x3½	29	220	10
34x3	31	175	9	34x3½	31	220	11
36x3	33	175	9	36x3½	33	220	11
32x4	29	325	14	32x5	29	400	18
34x4	31	325	16	34x5	31	400	19
36x4	33	325	17	36x5	33	400	21
38x4	35	325	18	38x5	35	400	23
40x4	37	325	19	40x5	37	400	23
42x4	39	325	20	42x5	39	400	24
32x6	29	475	21	36x7	33	550	28
34x6	31	475	23	38x7	35	550	30
36x6	33	475	24	40x7	37	550	31
38x6	35	475	26	42x7	39	550	33
40x6	37	475	27	36x8	33	550	29
42x6	39	475	29	40x8	37	550	33
1110x100 mm.	47	325	24	1000x125 mm.	43	400	27

The above gives an idea of the service which may reasonably be expected of a solid tire. If it is well built and of good material properly compounded, it will give

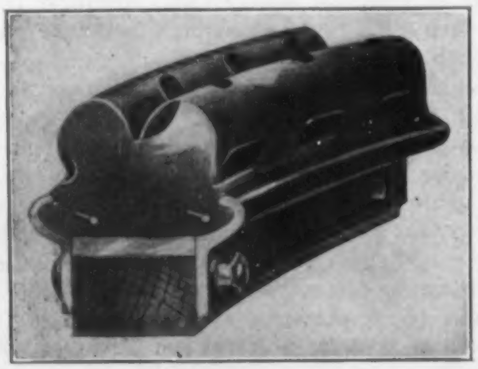


FIG. 10. CUSHION TIRE FOR ELECTRICS

good service, with the final provision that it receive fair treatment. It must not be overloaded, driven at speed higher than allowed, or run for long periods of time without being given a chance to cool off. When heavy loads are to be carried it is preferable in point of service to substitute duals for a single large tire. Thus where a 14-in. size is necessary two 7-in. tires will be found more satisfactory.

The compounding of solid tires is not easy. There are so many factors that must be handled to a nicety that it is hard to get the proper balance between them. The chief difficulties may be stated as follows:

(*a*) *Union:* The hard rubber must make good union with both tread and band.

(*b*) *Body and Hardness of Tread:* The stock used here must be heavily compounded so as to stand up well under the load. If it is too soft it will cut and large chunks will be torn out.

(*c*) *Easy Working:* The stock must be of a nature which will allow it to tube readily.

CUSHION TIRES

The cushion tire is a hybrid. It is both a solid and a pneumatic—and neither. It is merely a solid tire with a hole in it. The hole may be either inside or outside. There have been advanced more than a thousand designs based on this principle, but none of them ever become really popular. The reason is simple. If the tire is to function as a pneumatic, the walls of the air space are too heavy to stand the flexing without considerable heating up and subsequent decomposition.

The proposition is in some ways parallel to the tire filler (pneumatic). This phœnix is revived year after year, and sad to state the unsophisticated always fall for it. They forget that rubber is the most incompressible substance known. It can be easily deformed but never compressed. In designing a tire to carry a load one must first decide whether he will secure the desired cushioning solely by rubber itself or if air is more suitable. If after careful consideration of the conditions he decides on the first solution he will make a solid tire. If air is to be depended upon he will design the walls of his container in such a way that they will stand flexing.

The trouble with a cushion tire is that it will not stand any large amount of bending without suffering serious injury. In practically every instance where a cushion tire appears to give satisfaction it will be found that it has been very lightly loaded and the degree of flexing has not been high. One can safely say that there is no field for the cushion tire. Practically every application can be as well or better served by either a pneumatic or a solid. This does not mean that it may be substituted by both a pneumatic and a solid, but that one of the two will prove more satisfactory.

This statement must be qualified, however, since there is one very good place for the cushion tire with outside air spaces, and that is on small electrics. These cars are light, travel at slow speed over good streets, and are usually driven by women. Their advantage is twofold: first, the uneven surface gives it non-skid properties, and, second, there are no punctures. This fact means much to an elderly lady. To her the tire is reliable, for, like the famous flivver, "it gets you there and gets you back." She drives slowly, and the jolts are greatly decreased.

The manufacture of such tires is simple. The tube machine runs them out in sticks of the proper length and approximately the proper shape. The tires are built by hand. The fabric base is put on, and the tire spliced

in the usual way with the jammer. The knobs, depressions and special designs are put on in the molds during curing.

Stocks used for cushion tires are necessarily of a higher quality than for solids. They must have a higher tensile strength and higher stretch. The best of them will show a tensile strength of close to 3000 lb. per sq.in. and a stretch of 400 to 500 per cent.

Conclusion

The above is in general the history of solid tire development. During the war motor trucks were a deciding factor. They proved to be the red corpuscles not only of the battlefield but of industry. Every territory formerly dominated by the railroads has been seriously invaded. Surely the lessons learned in war will not be forgotten in peace. The next ten years will see the greatest truck expansion the world has ever known. With it will come extensive road building. The solid truck tire will dominate the field for a long time at least. Sales on pneumatic truck tires may be developed sufficiently to displace solids almost entirely, but the writer feels that an entirely new scheme of design will have to be worked out. Merely increasing the dimensions of the automobile tire will not prove successful.

The writer has attempted to set before the reader some of the salient features of solid tire design and manufacture, without going too much into detail. While the conclusions advanced are the result of his own observations and experience, he realizes very well that all solid tire men will not agree with him, and therefore offers them simply as his own opinions, which he believes in the main to be correct.

Our country undoubtedly faces a complete revision in transportation. Good roads will be constructed to every corner of the land. The bulk of our commerce will in the future be carried on trucks. Whether they will be equipped with solid or pneumatic tires is yet to be seen. It appears now that express trucks will ride pneumatics but that regular freight service will depend on solids. Good roads and plenty of gasoline or an efficient substitute will be found among the deciding factors.

Cleaning Furnace Gases Without the Use of Water

By J. C. Barrett

Superintendent of Blast Furnaces, Carnegie Steel Co., Youngstown District

REALIZING the inefficiency of the various methods of cleaning and burning blast-furnace gases, F. E. Kling, chief mechanical engineer, and Luther B. Weidlein, experimental engineer of the Ohio works, Carnegie Steel Co., Youngstown, Ohio, five years ago started experiments to overcome the difficulties. In the course of their experiments, they developed a very efficient gas burner for boilers, which is truly an aspirating burner and fulfills the rigid specifications required for burning blast-furnace gas efficiently. After completing this phase of the problem, steps were taken to make a comparison of results obtained from burning gas which had been cleaned or partly cleaned by various means, and dirty gas taken directly from the dust catcher.

The first experiment was carried out with gas that had passed through an impinging type of wet washer. This type of washer was found to be very inefficient, as it reduced the temperature about 50 per cent, was not more than 50 per cent efficient in removing the dust, and the gas picked up about 15 per cent additional moisture. The item of reduced temperature alone was sufficient to condemn this method, disregarding the high dust content of the gas. Aside from the loss of the sensible heat due to reduced temperature and increased moisture content of the gas, the quantity of dust which the gas carried through the washer was just as detrimental to obtaining boiler and hot-blast-stove efficiency is if the gas had not been cleaned at all.

The next experiment was made with gas that had passed through the cleaning plant for gas engines, which includes a spray tower, baffle tower, and Theisen washer. Even if the gas were desirable for boilers or hot-blast stoves, this method of cleaning would be prohibitive from the standpoint of cost. A disadvantage of this method, disregarding the cost, is the fact that the sensible heat of the gas is reduced to such a point that the usual size combustion chamber is not long enough to obtain complete combustion. The gases, therefore, enter the boiler proper partly unburnt, coming in contact with the heating surface of the boiler, which is the temperature of the steam, causing the gases to give up the heat of combustion, thereby reducing the temperature of the unburnt gases below the ignition temperature, with the consequent incomplete combustion of the gases, resulting in a loss that might otherwise be prevented.

The moisture content of the gas was reduced to about 30 per cent of the original with this method of washing. To accomplish this, however, it was necessary to reduce the temperature of the gas to the temperature of the water used for cleaning. If the temperature and the moisture content of the gas entering the boiler were the same as in the waste gases leaving the boiler, it would not be possible to sustain the loss of a single B.t.u. With any normal operating condition of the blast furnace, there is a decided advantage in favor of retaining the temperature of the gas as coming from the furnace, even in view of the fact that the gas contains the additional amount of moisture. An experiment was then made with hot gas taken directly from the dust catcher, and much better results and efficiencies were obtained than with either of the former experiments, although large quantities of dust had to be contended with, and the dust had to be blown off the boiler tubes frequently.

In view of the results obtained from the above experiments, and the advantages so prominent in favor of hot gas, various means were employed to develop a cleaning method in which the dust could be removed from the gas without reducing the temperature. After careful study and experiment, a very novel means of removing the dust from the gas was developed, and an experimental cleaner was built, designed to handle 6000 cu.ft. gas per minute at 62 deg. F. This plant was in operation, off and on, for about six months, being taken off and changed as various improvements were developed. Results were obtained that were truly remarkable in view of the difficult problem of removing the very fine or impalpable powder from the gases—results that equal and surpass cleaning efficiencies of the best types of wet washers.

The gas passing through this experimental cleaner

was consumed under a 400-hp. Stirling boiler, and after a month's operation, without blowing the tubes, there was less than 50 deg. F. increase in temperature of waste gases on account of the dust accumulation. What little dust came through the cleaner was of such nature that a large portion of it was carried through the boiler and out with the waste gases. However, the portion deposited on the tubes was easily removed by blowing it with a hand steam lance. The dust carried by gas which has been wet-washed bakes onto the tubes and is hard to remove. During a slip of the furnace, the dry cleaned gas would burn as usual, while the flame would extinguish in an adjoining boiler, using wet washed gas, due to excessive dust. The boiler was completely equipped with recording instruments, and it was shown that it would not be necessary to blow the tube oftener than once in two to three weeks to maintain almost uniform boiler efficiency.

This experimental cleaner was inspected by various individuals and committees, and was pronounced a remarkable development, and one which would revolutionize cleaning methods for blast-furnace gases. Due to the very satisfactory results obtained from the above experiment, the United States Steel Corporation authorized the installation of a cleaner large enough to clean all of the gas from one blast furnace. This cleaner was installed at No. 1 blast furnace of the Ohio works, Carnegie Steel Co., Youngstown, Ohio, and was built and ready for operation without interfering with the operation of the blast furnace, the latter being banked only long enough to make a connection to the existing dust catcher. This furnace has a capacity of 550 tons of iron per day, and produces 80,000,000 cu.ft. of gas which passes through the cleaner daily.

The cleaner proper was constructed of reinforced slag concrete due to the scarcity of steel plates during the war. The accompanying photograph shows the cleaner in course of construction. The idea of using concrete for this purpose is quite novel in itself. This structure was built to withstand an explosion pressure of 15 lb. per sq.in., and it is well equipped with explosion valves of special design, which are set to open at 1 lb. pressure per sq.in. The walls, being 15 in. thick, act as a very good insulator to retain the temperature of the gas. The concrete has shown no deterioration, and has withstood all conditions to which it will be subjected, and no trouble is anticipated.

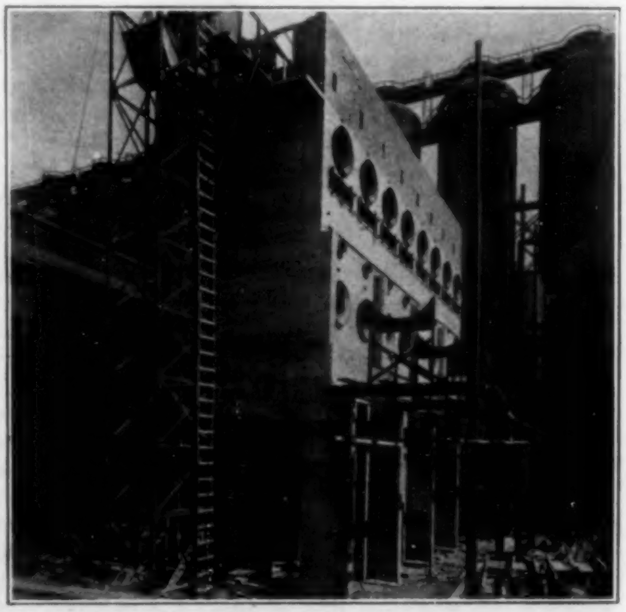
With inquiries favoring steel plate in preference to concrete, the inventors have designed a very adaptable construction which should appeal to the most skeptical. A course of Sil-o-cel insulating brick was used in addition to the regular lining of firebrick in the gas piping, as the idea of retaining the sensible heat in the gases was foremost in the minds of the inventors.

The operation of the cleaner is entirely automatic and does not require constant attendance. One of the men from the regular force maintained in blast-furnace operation inspects and lubricates the machinery once or twice a day.

That the project was well engineered is shown by the fact that the cleaner, when put in operation about two months ago, without any preliminary trials, worked satisfactorily, which is remarkable when considered that it is the first large installation of its kind. This cleaner has been in continuous operation since that time, which demonstrates that it is thoroughly reliable. The power required to operate this cleaner 25 per cent of the time is 4.25 hp., and 75 per cent. of the time 2 hp., making an average power requirement of 2.58 hp. as compared with 80 hp. to 100 hp. for wet washer. The dust is accumulated in hoppers of sufficient capacity to hold two or three days' accumulation. It is then dumped into standard hopper cars, the operation requiring only about one-half hour to remove the dust from the cleaner.

Since this cleaner has been in operation, an additional 25 per cent of dust in the gas leaving the dust catcher has been reclaimed. Heretofore, this was carried away in the water that was used for washing the gas, although it was supposed that very complete settling of the dust was being obtained in large settling basins. The average amount of dust deposited in this cleaner since starting operations is 63,500 lb. per 24 hr., although the gas has previously passed through a dust catcher 30 ft. in diameter. This represents 48.6 per cent of the total dust leaving the furnace by way of the downcomers. The cleaner is maintaining a cleaning efficiency of 90 to 97 per cent, the dust content in clean gas being 0.10 to 0.30 grains per cu.ft. at 62 deg. F.

The range of temperatures of the gases which have passed through this cleaner is 150 to 800 deg. F., and the average loss in temperature due to radiation is 25 deg. F. to 35 deg. F., with atmospheric temperature ranging down to 10 deg. F. There have been instances where the temperature of the outgoing gas has been



DRY GAS CLEANER

150 deg. F. higher than the incoming gas. This is due to a condition where the incoming gas was very low in temperature, the massive concrete walls having stored up the heat from gas of high temperature which previously passed through the cleaner, and giving it up to the gases of low temperature, the structure acting as a heat equalizer.

The resistance to flow or back pressure on the furnace is only 2 to 3 in. water gage. This includes all piping to and from the cleaner, and the cleaner itself. This is considerably lower than the resistance through any type of wet washer. The cleaner is connected to a blast furnace that has been in operation for four years on the present lining, and it has been subjected

to all of the conditions which are characteristic of an old furnace. The cost of an installation for cleaning gas by this method compares very favorably with the cost of a complete wet washing outfit; and considerably less ground space is required, due to the absence of settling basins.

The beneficial results from this method of cleaning are so pronounced that great interest has been shown in the form of inquiries and investigations, and they demonstrate the opportunities which are paramount in the field of dry cleaning furnace gases. During the comparatively short time that this method has been demonstrated, several additional installations have been contemplated at various places, including another cleaner to be built at the Ohio works. Adopting the method of dry-cleaning gas permits other changes in practice that appear on the whole to be very advantageous. By having hot gases enter the hot-blast stoves, it is possible to obtain higher flame temperature in the stoves, which will result in a saving of coke, since a higher hot-blast temperature will be available. It will be possible to operate the furnace with fewer stoves by equipping the stoves with smaller checkers, thereby obtaining better operating efficiency. An installation for cleaning all of the gas from a furnace would cost about the same as a hot-blast stove.

A summary of the advantages to be obtained by the dry cleaning over wet washing of furnace gases is as follows:

Sensible heat of the gas is retained.
When burned under boilers, the gas generates more steam.
When burned in hot-blast stoves, produces higher blast temperature.
No water is required for cleaning the gas.
No settling basins are required.
Less ground space required, due to absence of settling basins.
No pollution of streams.
Less labor cost in handling the dust.
Less than one-tenth the power required to operate.
Less back pressure on the furnace.
Cleaning efficiency as good as the best types of wet washers.
No sludge dripping from gas mains and burners.

Book Reviews

MILL AND CYANIDE HANDBOOK. By *A. W. Allen.* 128 pages, with diagrams and charts; price $2.00. Philadelphia: J. B. Lippincott Co.

This addition to the many handbooks recently issued has been planned to cover a narrow field. Its subject matter is devoted to the winning of the precious metals by amalgamation and cyanidation. The book is of English origin. It typifies English methods and draws its material largely from English sources. For instance, its tables consist in considerable part of data from South African practice, and thus may be explained the complete absence of concentration and of flotation data. From the American viewpoint, this circumstance is at once a strength and a weakness of the book—the one since it brings the reader useful data not easily available, the other by its inclusion of the conversion tables for English moneys and measures.

To readers of the technical press, who have known the author as a writer of exceptionally precise expression and of thorough acquaintance with his subject, the first impression of the book is distinctly disappointing. Closer examination discloses much useful matter, but this impression is never wholly dissipated. Criticism is somewhat disarmed by the author's statement that the data were collected prior to 1914. The book seems to lack systematic arrangement—a fault perhaps more of the publisher than of the author—and the matter is of unequal merit. The presentation of all data in tabular or graphic form is novel and is doubtless the logical method for a book of this class. The style offers some difficulties, as for instance in the description of assay methods, and it tempts to the expansion into a table of what could as well be compressed into a single line. Thus the weight of sheet-lead is readily derived from the weight of a unit volume of this material. Again, the matter in Section 5 could have been expressed more simply without loss.

The launder data—page 62—are insufficient. The general formulæ, as of Blue and Caldecott, are not given, and the valuable data of Washoe and Cananea, published a few years ago in the *Engineering & Mining Journal*, are missing. We find nothing of cyanide antidotes, or of volumes of conical classifiers, and not enough of weights of materials or of hydraulic equivalents.

The author's excellent formulæ for the calculation of extraction and of recovery are given. It is to be regretted that he deemed the scope of the book insufficient to include Hoover's formulæ for concentration. The tabular matter is followed by a series of typical flow-sheets, useful for reference, and these by a group of report-forms of rather doubtful value. An excellent glossary closes the volume.

Personal

MR. ROBERT J. ANDERSON has resigned as research metallurgist with the Bureau of Aircraft Production, Detroit, and will join the staff of the Bureau of Mines. He will make special investigation in the metallurgy of aluminium and other non-ferrous metals, at the experiment station at Pittsburgh.

MAJOR CHARLES V. BACON, who was engaged during the war on investigation relating to liquid fire and war gas, has been made chief of the Research Section of the Engineering and Standardization branch P. S. & T. division of the General Staff.

CAPT. C. L. COLBURN has returned from service with the Corps of Engineers, and has resumed his former work as assistant metal mining engineer for the Bureau of Mines, stationed in Washington.

DR. HENRY M. HOWE is to sail for Europe early in April for a stay of about three months.

MR. WALTER RENTON INGALLS, editor of *Engineering & Mining Journal* for nearly 14 years, has resigned to reenter professional practice as a consulting engineer, with offices at 115 Broadway, New York City.

DR. A. D. LITTLE recently addressed the Industrial Association in Cleveland on the industrial utilization of chemical research.

MR. DORSEY A. LYON, supervisor of stations for the Bureau of Mines, is on an extended Western trip of inspection.

CAPT. A. C. NELL, Construction Division, U. S. A., has been released from active duty in the Army, and has been appointed Chicago district manager for the Lea-Courtenay Co. and the Schutte & Koerting Co.

MR. H. C. PARMELEE, editor of CHEMICAL & METALLURGICAL ENGINEERING, has been appointed acting editor of the *Engineering & Mining Journal*, vice Mr. Walter Renton Ingalls, resigned.

MR. F. R. STILL, vice-president and secretary of the American Blower Co., has left on an extended trip for the Far East, where he will investigate trade conditions in connection with export work. His itinerary includes Japan, China, Australia and most of the European countries.

DR. T. B. WAGNER, chief chemist of the Corn Products Refining Co., New York City, has resigned to take a similar position with the United States Food Products Corp., 40 Exchange Pl., New York City, which has lately succeeded to the business of what was formerly known as the Distillers Securities Corporation.

Current Market Reports

The Non-Ferrous Metal Market

Monday, March 24.—Prices on the non-ferrous metal market are inviting to buyers and large transactions are impending.

Aluminium:—Conditions are unusually quiet, as aluminium has not declined. Ingots 98-99 per cent, 31c. lb. Sheets, 18 gage and heavier, 42c. Powder, 0.70-1.40 lb.

Antimony:—Wholesale lots are offered from 7c. to 7½c. and jobbing at 7½c. There is no active buying.

Copper:—No sustained buying has taken place, with prices as low as 15c. lb.

Copper sheets, hot-rolled	lb.	$0.22½— ......
Copper sheets, cold rolled	lb.	.23½— ......
Copper bottoms	lb.	.30½— ......
Copper rods	lb.	.19½— ......
Copper wire	lb.	.18 — ......
High brass wire and sheets	lb.	.18½— ......
High brass rods	lb.	.17½— ......
Low brass wire and sheets	lb.	.18½— ......
Low brass rods	lb.	.21½— ......
Brazed brass tubing	lb.	.29½— ......
Brazed bronze tubing	lb.	.33½— ......
Seamless copper tubing	lb.	.28 — ......
Seamless bronze tubing	lb.	.29½— ......
Seamless brass tubing	lb.	.30 — ......
Bronze (gold) powder	lb.	1.00 — ......

Lead:—No change has occurred with lead. East St. Louis quotes 4.90-5.00c. per lb. and New York 5½c. Sheet lead, 8-8½c. lb.

Tin:—The fixed price of 72½c. will remain until the 10,000-ton allotment is liquidated, which will be from sixty to ninety days yet.

Zinc:—Spelter remains unchanged, with East St. Louis prices showing no future decline from $123.50 per ton. Zinc dust, 14c. Sheet zinc, 11c. lb.

OTHER METALS

Bismuth	lb.	$3.20 — $3.65
Cadmium	lb.	1.40 — .....
Cobalt	lb.	2.50 — 3.50
Magnesium	lb.	1.75 — 2.10
Mercury 75	lb.	68.00 — .....
Nickel	lb.	.40 — .45
Tungsten	lb.	Nominal
Iridium	oz.	175.00 — .....
Palladium	oz.	115.00 — .....
Platinum	oz.	95.00 —100.00
Silver	oz.	1.01¼— .....

The Iron and Steel Market

A wide variety of opinion has been expressed on the price reductions made in pig iron, unfinished steel and finished steel products as a result of the activities of the Industrial Board of the Department of Commerce. This board, the conception and creation of Secretary of Commerce Redfield, undertook to deflate commodity prices, particularly those involved in construction work, for the purpose of stimulating business activity. As noted in last report, at a meeting of iron and steel purchasers March 6 there was a unanimous vote to co-operate with the board. A meeting between the industry's committee and the board was arranged for March 12, but was postponed one week. When the two bodies met, Wednesday morning, March 19, the producers' committee did not have a schedule of prices and asked for time to deliberate further, stating it would meet the board in the afternoon. Later it asked that the meeting be deferred until the following morning. It was not ready then, and it was not until 11.45 Thursday night that a partial schedule was completed. The producers put the reduced prices in effect as of the following morning, the precise time being important inasmuch as invoice prices of shipments of much finished steel hinged upon the price, the producers being disposed, according to trade custom, to give customers the advantage of any market declines.

Since the new prices were announced there has been some criticism of them by producers, though not a great deal, the disposition being to make the best of the situation. The adjustment may better be judged by opinions freely expressed in the trade before the new prices were formulated. There was then expressed very widely the opinion that steel prices should not be cut at all, or should be cut deeply. No small reduction, it was urged, at all comparable to the reduction of last December would do any good. A small reduction would cause the steel mills to receive less money for deliveries against orders already on books, while it would not stimulate or increase consumption. These utterances have proved unfortunate, since that is precisely the kind of a reduction that has been made. Members of the committee have been indisposed to divulge the nature of the discussions that kept them so long in reaching a conclusion, but one may perhaps guess that what was done represented a compromise between counsel for no reduction and counsel for a large reduction. The matter had been so widely advertised, and buyers were so generally holding back orders in anticipation of reductions that something had to be done.

Extent of Reductions

The reductions made were as follows: Pig iron, $4.25 per gross ton; unfinished steel, $5 per gross ton; wire products and grooved steel skelp, $5 per net ton; all other rolled steel products, $7 per net ton. The trade adopts the practice of applying the $4.25 reduction to the last Government prices, allowing for the $3 reduction previously made. War Industries Board extras, differentials, basings, etc., are to obtain. Obviously this will not work out for any length of time, since the furnacemen are not used to such an artificial price structure, nor indeed can it be fully maintained. The price of No. 2 foundry iron would be the same, $26.75, f.o.b. valley furnaces, Ironton furnaces, Chicago furnaces and Birmingham furnaces, and Birmingham could not reach a sufficient market, on account of freights. Immediately one small divergence occurred. More or less by chance, apparently, malleable iron had been set, under Government control, at 50c. above foundry iron, while foundry iron was $1 above basic. Normally much of the malleable iron produced is simply off basic. Immediately upon the announcement of the new prices a prominent valley furnace interest offered to sell malleable at 50c. above basic, which would be 50c. below foundry instead of 50c. above.

The new prices on unfinished steel are: Billets, $38.50; 2-inch billets, $42; sheet bars, $42; slabs, $41; rods, $52. All these products had been reduced $4 in December, except rods, which were not reduced. The new finished steel prices, in cents per pound, are: Bars, 2.35c.; shapes, 2.45c.; plates, 2.65c.; grooved steel skelp, 2.45c.; universal mill skelp, 2.55c.; sheared skelp, 2.65c.; merchant steel pipe, 57½ per cent basing discount; plain wire, 3c.; wire nails, $3.25 per keg; black sheets, 28 gage, 4.35c.; blue annealed sheets, 10 gage, 3.65c.; galvanized sheets, 28 gage, 5.70c.; tin plate, $7 per base box, 100-pound.

Price Comparisons

No. 2 foundry pig iron was $33 under Government control, advancing to $34 by the settlement late in September, 1918, becoming $30 about Jan. 1, 1919, and now declining to $26.75, basic iron being $1 less, while bessemer is $27.95. Foundry iron at valley furnaces 1904 to 1913 inclusive averaged $15.68. The ten-year pre-war average in billets was $24.82, the Government price being $47.50, while the present price is $38.50. A weighted average of bars, shapes, plates, pipe, wire products, sheets and tin plates shows the following, per net ton: Ten-year pre-war average, $36; Government limit, $76; after December reductions, $72; after March reductions, $65. Thus prices remain above the pre-war average as follows: Pig iron, 71 per cent; billets, 55 per cent; finished steel, 81 per cent.

Market Prospects

Both official statements on the price adjustment, that of Judge Gary, chairman of the producers' committee, and that of the Industrial Board, state in substance that the new prices are to be minimum for the remainder of the year. If, however, the price reduction does not greatly stimulate consumption the way will be open for a further consideration of the subject, say in June or September. The experience of the first few weeks after these reductions will not prove sufficient for a long range prediction. Buyers were making purchases only from hand to mouth, but even under that policy they were able to hold back orders for a short time, when they saw the prospect of reductions being

made. As the new prices would in any event hold for a time, buyers who are supplying ordinary everyday requirements are naturally buying freely and the market is moderately active. The rate of steel production, which was 85 per cent in January and only a shade less in February, had declined in March, but will probably hold at about 75 per cent for a while.

The investment buyer, on the other hand, cannot be heard from at once and it will require some time to observe how he takes the reduction. The investor, furthermore, considers other materials than steel, including lumber, brick, cement, etc. These and other commodities are still to be taken in hand by the Industrial Board and the investor will be disposed to wait and see what luck the board has with these commodities. Thus the real test of the new steel prices can hardly occur within the next month or two.

The steel trade has accepted the new arrangement as distinctly a price maintenance one, with support by the Industrial Board and absolution of the Department of Justice, with which department there was close contact during the negotiations. There is, however, an important divergence between the situation now and that which obtained during the price maintenance of 1908. At that time distribution of orders was arranged whereby all producers operated at substantially the same rate and thus there were no jealousies. In the past few weeks there has been a wide divergence in the rates at which the various producers have operated.

The Chemical Market

COAL-TAR PRODUCTS.—The situation in general has undergone no material change in the interim. While at this writing a firmer tendency prevails in the crudes, with buyers showing more interest than formerly and weak sellers fairly well cleaned out, the intermediates have not followed suit and if anything they are weaker than formerly, although quoted prices are about the same. The reason for the weakness in price of the intermediates is attributed in the main to the fact that more concerns are producing with unusually large quantities of surplus material on the market. Buyers, on the other hand, have not increased, and in fact have decreased, and those who were accustomed to laying in large stocks to bridge over eventualities find it unnecessary to do so while conditions continue as they are.

Phenol:—This market has firmed up considerably due to the elimination of several second hands who were holding large quantities for foreign governments. The inquiry has improved and though there are not as many large sales being closed as formerly, the volume of comparatively small sales is quite satisfactory in the aggregate.

Benzol:—It is still possible to shade producers' prices, due to the fact that large quantities are held in second hands, but prices are in the main well maintained in both quarters. A fair volume of business is passing, although the former tendency on the part of buyers to stock up for long periods has abated somewhat, and in most quarters they are buying only sufficient to cover for present requirements.

Toluol:—Buyers are displaying more interest than they have for some time past. Material is for the most part held by producers, with only limited quantities available in second hands, so that there is but little business passing through the latter hands and prices are on a firmer basis.

Naphthaline:—There is not a great deal of business passing in this item. Consumers appear to be indisposed to stock up for more than immediate requirements and the volume of business closed is not as great as sellers would like to see. Prices are, as a result, considerably easier.

Aniline Oil:—Large quantities of this material are available at present with only a moderate demand and some marked concessions in price have resulted. While producers are not generally inclined to reduce quoted prices, firm bids at less than quoted prices have been accepted.

Aniline Salt:—The increased output has resulted in a weaker position and in the desire to move material low prices have been accepted in several instances.

Paranitraniline:—A fairly active business is passing, but there are several concerns producing, with surplus stocks on the market and prices lower.

Salicylic Acid:—With little or no demand prevailing and large quantities on the market, prices are considerably lower.

Benzoate of Soda:—Both the soda and acid have felt the effect of curtailment of export demand and lower prices are in order as a result.

Salol:—The demand is not pressing and though there are sales of moderate quantities passing, the position is anything but firm.

Dimethylaniline:—Business is passing in fair volume but is considerably less than dealers can take care of, and despite attractive prices buyers are seemingly not greatly interested.

Anthracene:—A fairly active demand prevails, and with only a few producers in the field prices are fairly well maintained.

Resorcin:—The production is confined to a few quarters, with an active demand and prices unchanged.

HEAVY CHEMICALS.—Despite the fact that inducements in the way of what are considered attractive prices, buyers are seemingly disinclined to contract over long periods, or to buy more than sufficient material to cover current requirements. As a result, there is considerable gunning for business on the part of large producers and prices have, in a great many instances, been shaded in an endeavor to move surplus stocks. Such large business as is passing is generally confined to the filling of export orders, but even this avenue of consumption is considerably clogged up due to the present harbor strike and the resultant difficulty in moving material so that it will reach the vessels by sailing time. There is also considerable difficulty encountered in getting buyers on old contracts to accept material due to the drop in price.

Caustic Soda:—Compared with the few weeks preceding, the past week has seen some improvement in the volume of trading. Prices, however, have weakened, if anything, due to liberal offerings and the keen competition prevailing among the many holders. Sales of material f.a.s. have been made in exceptional cases as low as $2.60, although $2.70 to $2.75 is more representative of the prices prevailing in most instances. Material ex-warehouse sold at $2.55 to $2.60 on the average. A sale of a goodly quantity of resale material threatened, for a time, to have a disturbing effect, but it was subsequently withdrawn from the market.

Soda Ash:—Although some very liberal inducements are made to buyers, they do not appear to be inclined to buy heavily, and such business as is passing is for very small quantities. The general outlook based upon conditions prevailing the past few weeks appears to have a depressing effect on the market. Sales were made ex-warehouse in bags at $1.55 to $1.60.

Bleaching Powder:—The arrival of large quantities on the market, with such buying interest as there is confined to export orders and these not heavy, has caused an easier price position, although quotations in general are unchanged. Export drums are available at $2.25, with domestic drums at $1.60 to $1.65.

Copper Sulphate:—Comparatively large sales are being closed and it is possible to shade prices in a great many instances. From $7.15 to $7.25 is quoted for outside brands, with standard brands somewhat higher.

Formaldehyde:—There is an active business passing in this item, but stocks are ample and sales have been closed at 22c. in the past week.

Sodium Sulphide:—Buying pressure is not heavy and sales are passing here and there at a shade under former prices.

Nitrate of Soda:—There are only small lots of 25 to 50 tons in all that are available on the resale market, at $4.05 to $4.07½. The Government-fixed price of $4.07½ continues to be maintained.

Glycerine:—The bulk of sales passing is for small quantities, and prices are somewhat lower.

Calcium Carbide:—There is only a moderate volume of business passing and from time to time concessions in price are made, with 6¼c. to 6½c. quoted.

Arsenic:—Such sales as are passing are for comparatively small quantities. The white material, which is in fair demand, is quoted at 9c. to 9½c. The red is quite neglected, with 26c. to 31c. quoted.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET MARCH 24, 1919

Acetic anhydride	lb.	.90	—	1.00
Acetone	lb.	.15½	—	.16
Acid, acetic, 28 per cent	cwt.	3.25	—	3.40
Acetic, 56 per cent	cwt.	6.50	—	6.75
Acetic, glacial, 99½ per cent, carboys	cwt.	14.00	—	14.50
Boric, crystals	lb.	.13½	—	.15
Citric, crystals	lb.	1.25	—	1.25½
Hydrochloric, (22%)	cwt.	2.50	—	3.00
Hydrofluoric, 30 per cent, in barrels	lb.	.08	—	.08½
Lactic, 44 per cent	lb.	.15	—	.16
Lactic, 22 per cent	lb.	.06	—	.07
Molybdic, C. P	lb.	6.90	—	7.40
Nitric, 36 deg	lb.	6.60	—	6.85
Nitric, 42 deg	lb.	.08½	—	.10
Oxalic, crystals	lb.	.32	—	.34
Phosphoric, 47-50 per cent paste	lb.	.07½	—	.10
Phosphoric, ref. 50 per cent	lb.	.26	—	.30
Picric	lb.	.50	—	.75
Pyrogallic, resublimed	lb.	2.70	—	3.20
Sulphuric, 60 deg. works	ton	12.00	—	14.00
Sulphuric, 66 deg. works, tank cars	ton	17.00	—	25.00
Sulphuric, oleum (fuming), tank cars	ton	25.00	—	26.00
Tannic, U. S. P., bulk	lb.	1.40	—	1.50
Tartaric, crystals	lb.	.86½	—	.87
Tungstic, per lb. of W	lb.	1.60	—	1.75
Alcohol, sugar cane, 188 proof	gal.	4.91	—	.....
Alcohol, wood, 95 per cent	gal.	1.28	—	1.30
Alcohol, denatured, 180 proof	gal.	.40	—	.42
Alum, ammonia lump	lb.	.04½	—	.05½
Alum, chrome ammonium	lb.	.17½	—	.18
Alum, chrome potassium	lb.	.20	—	.22
Alum, chrome sodium	lb.	.12½	—	.13
Alum, potash lump	lb.	.10	—	.12
Aluminium sulphate, technical	lb.	.02	—	.02½
Aluminium sulphate, iron free	lb.	.03	—	.03½
Ammonia aqua, 26 deg., carboys	lb.	.07	—	.08½
Ammonia, anhydrous	lb.	.30	—	.35
Ammonium carbonate	lb.	.13	—	.14
Ammonium nitrate	lb.	.16	—	.17
Ammonium sulphate, domestic	lb.	.05¼	—	.05½
Amyl acetate	gal.	3.50	—	3.75
Arsenic, white	lb.	.09½	—	.10
Arsenic, red	lb.	.35	—	.40
Barium carbonate, 99 per cent	ton	80.00	—	90.00
Barium carbonate, 97-98 per cent	ton	65.00	—	67.00
Barium chloride	ton	70.00	—	80.00
Barium sulphate (blanc fixe, dry)	lb.	.03½	—	.04
Barium nitrate	lb.	.10	—	.11
Barium peroxide, basis 70 per cent	lb.	.30	—	.32
Bleaching powder, 35 per cent chlorine	lb.	.01¾	—	.02¼
Borax, crystals, sacks	lb.	.07¾	—	.08¼
Brimstone, crude	ton	28.00	—	35.00
Bromine, technical	lb.	.55	—	.60
Calcium acetate, crude	lb.	.04	—	.05
Calcium carbide	lb.	.06¼	—	.06½
Calcium chloride, 7-75 per cent, fused, lump	ton	18.00	—	22.00
Calcium peroxide	lb.	1.50	—	1.70
Calcium phosphate	lb.	.22	—	.23
Calcium sulphate, 98-99 per cent	lb.	.09	—	.09½
Carbon bisulphide	lb.	.07	—	.08
Carbon tetrachloride, drums	lb.	.14	—	.15
Carbonyl chloride (phosgene)	lb.	.75	—	1.00
Caustic potash, 88-92 per cent	lb.	.50	—	.60
Caustic soda, 76 per cent	100 lb.	2.60	—	2.75
Chlorine, liquid	lb.	.10	—	.12
Cobalt oxide	lb.	1.60	—	1.65
Copperas	lb.	.01½	—	.02½
Copper carbonate	lb.	.31	—	.32
Copper cyanide	lb.	.65	—	.70
Copper sulphate, 99 per cent, large crystals	lb.	7.15	—	7.50
Cream of tartar, crystals	lb.	.55	—	.58
Epsom salt, bags, U. S. P	100 lb.	2.75	—	.....
Formaldehyde, 40 per cent	lb.	.22	—	.22¼
Glauber's salt	lb.	.02	—	.02½
Glycerine, bulk, C.P	lb.	.17½	—	.18
Iodine, resublimed	lb.	4.25	—	4.30
Iron oxide	lb.	.06	—	.08
Lead acetate, white crystal	lb.	.12¾	—	.14
Lead arsenate (paste)	lb.	.15	—	.18
Lead nitrate, C. P	lb.	.85	—	.86
Litharge, American	lb.	.10	—	.11
Lithium carbonate	lb.	1.50	—	.....
Magnesium carbonate, technical	lb.	.16	—	.17
Nickel salt, single	lb.	.14	—	.15
Nickel salt, double	lb.	.12	—	.13
Phosgene (see carbonyl chloride)	lb.	.75	—	1.00
Phosphorus, red	lb.	.75	—	.80
Phosphorus, yellow	lb.	.35	—	.40
Potassium bichromate	lb.	.37	—	.38
Potassium bromide, granular	lb.	1.25	—	1.26
Potassium carbonate, calcined, 85-90 per cent	lb.	.17	—	.18
Potassium chlorate, crystals	lb.	.39	—	.41
Potassium cyanide, 98-99 per cent	lb.	2.50	—	2.75
Potassium iodide	lb.	3.75	—	3.80
Potassium muriate, 80-85 p. c. basis of 80 p. c.	ton	200.00	—	250.00
Potassium nitrate	lb.	.26	—	.30
Potassium permanganate, U. S. P	lb.	.80	—	.82
Potassium prussiate, red	lb.	1.50	—	1.60
Potassium prussiate, yellow	lb.	.55	—	.58
Potassium sulphate, 90-95 p. c. basis 90 p. c.	ton	Nominal		
Rochelle salts	lb.	.46½	—	.48
Salammoniac, gray gran	lb.	.14	—	.16
Salammoniac, white gran	lb.	.12½	—	.13
Sal soda	100 lb.	1.60	—	2.00
Salt cake	ton	20.00	—	22.00
Silver cyanide, based on market price of silver	oz.	.....		.....
Silver nitrate	oz.	.62¾	—	.63¾
Soda ash, 58 per cent, light, flat (bags)	100 lb.	1.55	—	1.60
Soda ash, 58 per cent, dense, flat	100 lb.	2.45	—	3.00
Sodium acetate	lb.	.07¾	—	.08
Sodium bicarbonate, domestic	lb.	.02¾	—	.03
Sodium bicarbonate, English	lb.	.....	—	.....
Sodium bichromate	lb.	.12	—	.14
Sodium bisulphite, powd	lb.	.05	—	.07
Sodium chlorate	lb.	.16	—	.18
Sodium cyanide	lb.	.30	—	.31
Sodium fluoride, commercial	lb.	.14	—	.15
Sodium hyposulphite	100 lb.	3.25	—	3.75
Sodium molybdate, per lb. of Mo	lb.	2.50	—	.....
Sodium nitrate, 95 per cent	100 lb.	4.07½	—	.....
Sodium nitrite	lb.	.13	—	.14
Sodium peroxide	lb.	.25	—	.30
Sodium phosphate	lb.	.03½	—	.03¾
Sodium prussiate, yellow	lb.	.22	—	.24
Sodium silicate, liquid (60 deg.)	lb.	.05	—	.05½
Sodium sulphide, 30 per cent, crystals	lb.	.02	—	.02¾
Sodium sulphide, 60 per cent, fused	lb.	.04¾	—	.05
Sodium sulphite	lb.	.05¾	—	.06¼
Strontium nitrate	lb.	.25	—	.30
Sulphur chloride, drums	lb.	.07½	—	.09
Sulphur dioxide, liquid, in cylinders	lb.	.12	—	.15
Sulphur, flowers, sublimed	100 lb.	3.05	—	3.15
Sulphur, roll	100 lb.	2.70	—	3.10
Sulphur, crude	ton	35.00	—	37.50
Tin bichloride, 50 deg	lb.	.27¾	—	.28
Tin oxide	lb.	.65	—	.70
Zinc carbonate	lb.	.18	—	.20
Zinc chloride	lb.	.14	—	.14½
Zinc cyanide	lb.	Nominal		
Zinc dust, 350 mesh	lb.	.12	—	.13
Zinc oxide, American process, works	lb.	.10	—	.12
Zinc sulphate	lb.	.03¾	—	.04

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.20	—	.25
Benzol, 90 per cent	gal.	.25	—	.....
Toluol, in tank cars	gal.	.25	—	.....
Toluol, in drums	gal.	.30	—	.35
Xylol, pure, water white	gal.	.45	—	.55
Solvent naphtha, water white	gal.	.20	—	.25
Solvent naphtha, crude, heavy	gal.	.15	—	.17
Creosote oil, 25 per cent	gal.	.45	—	.55
Dip oil, 20 per cent	gal.	.40	—	.45
Pitch, various grades	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent	lb.	Nominal		
Carbolic acid, crude, 50 per cent	lb.	Nominal		
Carbolic acid, crude, 25 per cent	lb.	Nominal		
Cresol, U. S. P	lb.	.18	—	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00	—	1.10
Alpha naphthol, refined	lb.	1.20	—	1.25
Alpha naphthylamine	lb.	.45	—	.50
Aniline oil, drums extra	lb.	.24	—	.25
Aniline salts	lb.	.36	—	.40
Anthracene, 80 per cent	lb.	.50	—	.55
Benzaldehyde (f.f.c.)	lb.	2.50	—	2.60
Benzidine, base	lb.	1.00	—	1.15
Benzidine, sulphate	lb.	.95	—	1.00
Benzoic acid, U. S. P	lb.	1.20	—	1.25
Benzoate of soda, U. S. P	lb.	1.20	—	1.25
Benzyl chloride	lb.	.50	—	.....
Beta naphthol benzoate	lb.	5.50	—	6.00
Beta naphthol, sublimed	lb.	.55	—	.65
Beta naphthylamine, sublimed	lb.	2.50	—	2.55
Dichlorbenzol	lb.	.15	—	.20
Diethylaniline	lb.	2.25	—	2.75
Dinitrobenzol	lb.	.30	—	.35
Dinitrochlorbenzol	lb.	.30	—	.35
Dinitronaphthaline	lb.	.50	—	.55
Dinitrotoluol	lb.	.40	—	.50
Dinitrophenol	lb.	.38	—	.40
Dimethylaniline	lb.	.55	—	.60
Diphenylamine	lb.	.70	—	.75
H-acid	lb.	2.35	—	2.75
Metaphenylenediamine	lb.	1.55	—	1.75
Monochlorbenzol	lb.	.15	—	.17
Naphthalene, flake	lb.	.07	—	.08
Naphthalene, balls	lb.	.10½	—	.11½
Naphthionic acid, crude	lb.	1.20	—	1.30
Naphthylamin-di-sulphonic acid	lb.	1.00	—	1.10
Nitro naphthaline	lb.	.40	—	.45
Nitro toluol	lb.	.55	—	.60
Ortho-amidophenol	lb.	6.00	—	7.00
Ortho-dichlor-benzol	lb.	.15	—	.20
Ortho-toluidine	lb.	.45	—	.50
Ortho-nitro-toluol	lb.	.45	—	.50
Para-amidophenol, base	lb.	3.25	—	3.65
Para-amidophenol, H. C. L.	lb.	3.50	—	3.75
Para-dichlor-benzol	lb.	.15	—	.20
Paranitraniline	lb.	1.25	—	1.35
Para-nitro-toluol	lb.	1.50	—	1.60
Paraphenylenediamine	lb.	3.25	—	3.50
Para toluidine	lb.	1.80	—	1.85
Phthalic acid anhydride	lb.	2.50	—	3.00
Phenol, U. S. P	lb.	Nominal		
Resorcin, technical	lb.	4.50	—	5.00
Resorcin, pure	lb.	7.00	—	8.00
Salicylic acid, U. S. P	lb.	.35	—	.40
Salol	lb.	.95	—	1.00
Sulphanilic acid, crude	lb.	.25	—	.31
Toluidine	lb.	2.45	—	.....
Toluidine-mixture	lb.	.80	—	1.00

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4.00	—	.....
Corning, Ohio	bbl.	2.85	—	.....
Somerset, Ky	bbl.	2.60	—	.....
Wooster, Ohio	bbl.	2.85	—	.....
Indiana	bbl.	2.28	—	.....
Illinois	bbl.	2.25	—	.....
Oklahoma and Kansas	bbl.	2.25	—	.....
Caddo, La., light	bbl.	2.10	—	2.25
Corsicana, Tex., light	bbl.	2.25	—	.....
California	bbl.	1.24	—	1.57
Gulf Coast	bbl.	1.25	—	1.30
Mexican	bbl.	1.90	—	.....

Fuel Oil

New York	gal.	.15	—	.....
Philadelphia	gal.	.10½	—	.....
Baltimore	gal.	.07½	—	.15
Pittsburgh	gal.	.07½	—	.10½
Texas	bbl.	1.85	—	2.10
Los Angeles	bbl.	1.65	—	.....

Gasoline (Wholesale)

New York, motor	gal.	.24½	—	.....
Gas machine	gal.	.41½	—	.....
72-76 degrees	gal.	.33½	—	.39½
70-72 degrees	gal.	.32	—	.37½
67-70 degrees	gal.	.30½	—	.36½
Pittsburgh, motor	gal.	.24¾	—	.....
Chicago, motor	gal.	.23	—	.....
Oklahoma, motor	gal.	.23½	—	.....
San Francisco, motor	gal.	.20½	—	.....

Paraffine Waxes

Crude, 103 to 105 deg. m.pt	lb.	.08½	—	.09
Crude, 118 to 120 deg. m.pt	lb.	.09½	—	.10
Crude, 124 to 126 deg. m.pt	lb.	.10	—	.....
Refined, 120 deg. m.pt	lb.	.12	—	.12½
Refined, 128 deg. m.pt	lb.	.14	—	.....
Refined, 135 deg. m.pt	lb.	.15	—	.15½
Refined 140 deg. mp	lb.	.17½	—	.....
Ozokerite, green	lb.	.85	—	.90

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.20	—	.30
Cylinder, light	gal.	.38	—	.42
Cylinder, dark	gal.	.39	—	.43
Paraffine, high viscosity	gal.	.40	—	.41
Paraffine, 0.903 sp. gr	gal.	.32	—	.33
Paraffine, 0.865 sp. gr	gal.	.29	—	.35

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f. o. b. Florida	gal.	.44	—	.....
Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.58	—	.60
Pine oil, destructively distilled	gal.	.58	—	.60
Pine-tar oil, sp. gr. 1.02-1.035	gal.	.35	—	.....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.42	—	.....
Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37	—	.....
Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.28	—	.....
Pine-tar oil, ref., thin, sp. gr., 1.060-1.080	gal.	.32	—	.....
Turpentine, crude, sp.gr. 0.870-0.900	gal.	.45	—	.....
Hardwood oil, f.o.b. Michigan, sp.gr. 0.960-0.990	gal.	.23	—	.....
Hardwood oil, f.o.b. Michigan, sp.gr. 1.06-1.08	gal.	.23	—	.....
Wood creosote, ref., f.o.b. Florida	gal.	.31	—	.....

Naval Stores

Rosin A-E barrel	280 lb.	12.20	—	12.30
Rosin F-I	280 lb.	12.35	—	12.80
Rosin K-N	280 lb.	13.50	—	14.50
Rosin WG-W	280 lb.	15.25	—	15.50
Spirits of turpentine	gal.	.75	—	.....
Wood turpentine, steam distilled	gal.	.64	—	.65
Wood turpentine, destructively distilled	gal.	.63	—	.65½
Pitch	bbl. 220 lb.	8.00	—	.....
Tar, kiln dried	280 lb.	13.00	—	13.50
Retort tar	280 lb.	14.00	—	14.50
Rosin oil, first run	gal	.74	—	.....
Second run	gal.	.76	—	.....
Third run	gal.	.82	—	.....
Fourth run	gal.	.92	—	.....

Vegetable Oils

Castor oil	lb.	.21	—	.29
China wood oil	lb.	.19	—	.21
Cocoanut oil	lb.	.12½	—	.18
Corn oil	lb.	.13	—	.17
Cottonseed oil, crude	lb.	.17½	—	.22
Linseed oil, raw, cars	gal.	1.50	—	1.53
Palm	lb.	.14½	—	.23½
Peanut oil, crude	lb.	.14½	—	.21
Soya bean oil, Manchuria	lb.	.12½	—	.16

Glues

Extra white	lb.	.35	—	.40
Cabinet	lb.	.25	—	.26
Brown foot stock	lb.	.15	—	.19
Fish glue, 50-gal. barrels	gal.	1.00	—	1.50

Miscellaneous Materials

Barytes, floated, white domestic	ton	33.00	—	36.00
Beeswax, white, pure	lb.	.63	—	.65
Beeswax, unbleached	lb.	.40	—	.48
Blanc fixe	lb.	.05½	—	.....
Casein	lb.	.18	—	.22
Chalk, light, precipitated, English	lb.	.04½	—	.06
China clay, imported, lump	ton	20.00	—	40.00
China clay, domestic, lump	ton	15.00	—	22.50
Feldspar	ton	8.00	—	12.00
Fluorspar, gravel, f. o. b. mines	ton	25.00	—	32.00
Fluorspar, washed, powdered	ton	90.00	—	.....
Fuller's earth, powdered	100 lb.	1.50	—	2.00
Graphite Alabama	lb.	.08	—	.12
Ceylon	lb.	.09	—	.22
Madagascar	lb.	.10	—	.15
Mexican	ton	35.00	—	75.00
Japan wax	lb.	.12	—	.14
Orange shellac	lb.	.49	—	.64
Pumice stone	lb.	.04	—	.08
Soapstone	ton	.12	—	.17
Stearic acid	lb.	.17	—	.19½
Talc, American, white	ton	20.00	—	40.00

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	100.00	—	120.00
Chrome cement	net ton	65.00	—	.....
Clay brick, first quality fireclay	per 1000	40.00	—	47.00
Clay brick, second quality	per 1000	35.00	—	40.00
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined, powdered	ton	50.00	—	65.00
Magnesite, dead burned	net ton	38.00	—	40.00
Magnesia brick, 9x4½x2½	net ton	90.00	—	.....
Silica brick	per 1000	45.00	—	55.00

Ferroalloys

Ferrocarbontitanium. 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y.	ton	200.00	—	250.00
Ferrocerium	lb.	15.00	—	30.00
Ferrochromium, per lb. of Cr	lb.	.30	—	.40
Ferromanganese, domestic, 70 per cent basis	ton	150.00	—	.....
Spiegeleisen (16-18%)	ton	45.00	—	50.00
Ferromolybdenum, per lb. of Mo	lb.	3.50	—	4.50
Ferrosilicon, 50 per cent, contract	ton	120.00	—	125.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	Nominal		
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.50	—	.....
Ferrovanadium, f.o.b. works	lb.	.....	—	.....

Ores and Semi-finished Products

Chrome ore, 35%, per unit	ton	.80	—	.....
Chrome, Caledonia, 50%, per unit	ton	1.00	—	.....
Coke	ton	6.00	—	7.00
Petroleum coke	ton	16.00	—	.....
Manganese ore, 48 per cent and over, per unit	ton	1.20	—	.....
Manganese ore, chemical	ton	75.00	—	85.00
Molybdenite, per lb. of MoS_2	lb.	.75	—	.85
Tungsten, Scheelite, per unit of WO_3	ton	10.00	—	12.00
Tungsten, Wolframite, per unit of WO_3	ton	7.00	—	9.00
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	lb.	10.50	—	.....
Pyrites, foreign	unit	.17	—	.....

Plant Supplies

BUILDING MATERIALS

Common clay bricks	M	14.00	—	15.00
Faced brick	M	37.00	—	46.00
Hollow tile, 4x12x12	M	56.00	—	86.00
Hollow tile, 12x12x12	M	162.00	—	218.00
Lime	ton	17.50	—	.....
Portland cement	bbl.	3.45	—	3.62
Single glass (82-lb.), 10x26-16x24		21.00	—	27.00
Double glass (164 lb.), 10x26-16x29		31.00	—	39.00
Yellow pine lumber	M	39.00	—	45.00
Cypress	M	70.00	—	.....
Tarred felt (14-lb. sq.)	ton	52.00	—	55.00
Roofing pitch	ton	18.00	—	22.00
Asphalt coated roofing (35-55-lb.sq.)	sq.	1.60	—	2.45
Slate surfaced asphalt shingles	sq.	5.25	—	5.50
Corrugated galvanized iron	ton	100.00	—	.....
Putty	100 lb.	6.00	—	.....
Red oxide (Ppte. Copperas)	100 lb.	15.00	—	20.00
Native red oxide	100 lb.	3.25	—	5.00
Red metallic paint	100 lb.	1.20	—	1.50
White lead in oil	100 lb.	13.00	—	.....
White lead (dry)	100 lb.	9.00	—	.....
Red lead in oil	100 lb.	14.50	—	.....
Red lead (dry)	100 lb.	13.00	—	.....
Zinc oxide (dry)	100 lb.	12.00	—	13.00
Zinc oxide—leaded	100 lb.	8.50	—	10.00
Yellow ochre	100 lb.	1.50	—	10.00
Ultra marine blue	100 lb.	14.00	—	50.00
Prussian blue	100 lb.	135.00	—	150.00
Chrome green	100 lb.	35.00	—	60.00
Paris green	100 lb.	37.00	—	.....
Mineral black	100 lb.	1.75	—	2.25
Powdered bone black	100 lb.	5.50	—	12.00
Lampblack	100 lb.	15.00	—	45.00
Gas carbon	100 lb.	16.00	—	25.00
Mexican petroleum pitch	100 lb.	1.00	—	2.00
Gilsonite	100 lb.	2.00	—	2.50
Coal tar pitch	100 lb.	.60	—	1.25

STRUCTURAL IRON

Blue annealed sheet iron	ton	71.00	—	76.00
Black sheet iron	ton	87.00	—	.....
Galvanized iron	ton	101.00	—	.....
Tern plate, 8-lb. coating	ton	141.00	—	.....
Tern plate, 15-lb. coating	ton	175.00	—	.....
Tern plate, 25-lb. coating	ton	200.00	—	.....
Tern plate, 40-lb. coating	ton	230.00	—	.....
Tin plate, prime	ton	140.00	—	.....
Tank plates	ton	53.00	—	57.00
Beams, channels, angles, T's, Z's	ton	49.00	—	54.00
Rivets	ton	84.00	—	.....
Steel pipe, ½ to 3-inch	ton	51.00	—	.....
Bar iron	ton	62.00	—	.....
Chain (1 inch proof coil)	ton	150.00	—	.....
Nails, bolts, nuts, washers	ton	65.00	—	80.00
Tool steel, special alloys	ton	300.00	—	500.00
Bessemer pig iron	ton	29.35	—	.....
Bessemer steel	ton	38.50	—	.....
No. 2 foundry	ton	32.00	—	.....

POWER HOUSE SUPPLIES

Steam packing, rubber duck	lb.	.99	—	1.10
Asbestos, high pressure	lb.	1.76	—	.....
Asbestos, wired	lb.	1.30	—	.....
Asbestos, graphited braid	lb.	1.21	—	.....
Asbestos, wick	lb.	.75	—	.....
Rubber, sheet	lb.	.66	—	.....
Cup grease	lb.	.07	—	.....
Transmission grease	lb.	.07	—	.....
Axle grease	lb.	.04½	—	.....
Gear grease	lb.	.04½	—	.....
Cotton waste	lb.	.08½	—	.11
Hose, underwriters, 2½ in	ft.	.75	—	.....
Hose, air, ¾ in	ft.	.50	—	.60

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

DADEVILLE — The Dadeville Naval Stores Co. plans to install a turpentine distillery. J. D. Arnold, Dadeville, interested.

California

FRESNO—The Union Oil Co., Divisadero and Roosevelt Sts., plans to build an addition to its oil distributing plant; also six substations. Estimated cost, $200,000.

LOS ANGELES—The Bonnie-Reed Film Manufacturing Co., Niles, plans to build a motion picture plant, on Sunset Boulevard and Bronson Ave., to include laboratories, power plant, offices, etc. Total estimated cost, $1,000,000. Train & Williams, 225 Exchange Bldg., architect.

PORTERVILLE—The city trustees are having plans prepared by Olmsted & Gillelen, engineers, Hollingsworth Bldg., Los Angeles, for the construction of a gas plant.

RICHMOND—The Standard Oil Co., 200 Bush St., San Francisco, has awarded the contract for the construction of a 3-story laboratory, here, to P. J. Walker & Co., Monadnock Bldg., San Francisco. Estimated cost, $175,000.

VERNON—The Pan-American Petroleum Co., Security Bldg., Los Angeles, will build an oil refinery on a 12-acre site in the industrial district here, for the manufacture of greases and paraffine products. Estimated cost, $250,000. T. D. Boyce, care of company, engineer.

Colorado

EMPIRE—The Empire Gold Mining, Milling & Tunnel Co. plans to build a 50-ton concentrating mill and is in the market for milling plant equipment and lumber. Estimated cost, $50,000. W. A. Snyder, superintendent.

GEORGETOWN—The Georgetown Tunnel & Transportation Co. plans to build a crushing and concentrating mill and is in the market for a crusher, motor concentrating tables, etc. Address C. A. Basse, 608 Dearborn St., Chicago, Ill., secretary.

Connecticut

HARTFORD—The Board of Water Commissioners received bids for the construction of a filtration plant, from the Foundation Co., 233 Broadway, New York City, $627,507; F. T. Ley & Co., 495 Main St., Springfield, Mass., $632,619; H. E. Fox Construction Co., Inc., 81 East 125th St., New York City, $668,955. Noted Feb. 15.

PLAINVILLE—Landers, Frary & Clark, Commercial and Centre Sts., has awarded the contract for the construction of a 4-story, 60 x 100 ft. factory on Woodford Ave., for the manufacture of celluloid, to the Torrington Building Co., 197 Water St., Torrington. Estimated cost, $50,000.

Florida

JACKSONVILLE—The Virginia-Carolina Chemical Co., 11 South 12th St., Richmond, Va., plans to build a modern fertilizer plant on Talleyrand Ave., here. Estimated cost, $200,000.

Illinois

CHICAGO—Armour & Co., Union Stock Yards, has awarded the contract for the construction of a 2-story, 40 x 80 ft. glycerine distilling plant at 1355 West 31st St., to J. L. Carnegie & Sons, 189 West Madison Ave. Estimated cost, $15,000.

CHICAGO—The Peoples Gas, Light & Coke Co., 122 South Michigan Ave., plans to build a gas tank, having a capacity of 50,000,000 cu.ft. of gas per annum, at Crawford Ave. and 36th St. Estimated cost, $15,000,000. R. Schenck, care of owner, engineer.

Indiana

CHESTERTON—The Gary Chemical Co., recently incorporated with $50,000 capital, plans to build a plant for the manufacture of chemicals and medicinal preparations. V. U. Young, Gary, general manager.

EAST CHICAGO—The East Chicago & Indiana Harbor Water Co., 113 Monument Circle, Indianapolis, has awarded the contract for the construction of a new filtration plant, to the Warner Construction Co., 189 West Madison St., Chicago, Ill. Estimated cost, $333,000. Noted Feb. 15.

Kansas

BLUE MOUND—The Commerce Mining & Royalty Co., Miami, Okla., plans to build a sludge mill to handle sand tailings at Webber mine, and is in the market for tables, motor, rolls, elevators and transmission belting. Estimated cost, $10,000. J. Newton, general superintendent.

TREECE—The King Brand Mining Co., Picher, Okla., plans to build a concentrating plant here. Estimated cost, $100,000. W. Landrum, superintendent.

TREECE—The Wachusetts Mining Co., Commerce, Okla., plans to build a mill here. A. Mayerhoff, superintendent.

Maryland

HAGERSTOWN—The Maryland Smelting & Refining Co., West Church St., has awarded the contract for installing a brass-smelting furnace, having 1 ton capacity, a complete metal concentrating plant and metallurgical laboratory, to the Universal Engineering Corp., 1229 Calvert St., Baltimore.

SOLLERS STATION (Sollers P. O.)—The Aluminum Ore Products Co., Inc., 800 Maryland Trust Bldg., Baltimore, plans to enlarge its plant here. Estimated cost, $8,000,000. J. E. Aldred, chairman of the board of directors of the Consolidated Gas, Electric Light & Power Co., Lexington Bldg., Baltimore, interested.

Massachusetts

CHATHAM—The Bureau of Yards and Docks, Navy Department, Washington, D. C., plans to build a septic tank and sewage disposal plant here. Estimated cost, $75,000.

NEW BEDFORD—W. A. Robinson & Co., 144 South Water St., plans to rebuild its plant for the manufacture of oil, recently destroyed by fire, entailing a loss of $75,000.

WORCESTER—The Morgan Spring Co., West Boylston St., plans to build a 1-story, 41 x 80 ft. addition to its main plant to be used as a rolling mill.

Michigan

DETROIT—J. G. Kastler & Co., architects, 523 Chamber of Commerce Bldg., will soon award the contract for the construction of a 2-story, 120 x 150 ft. brass foundry, for Lokomsky Bros., Dubois St. and East Grand Boulevard.

Missouri

PLATTSBURG—The city plans an election soon to vote on a $70,000 bond issue for a new waterworks system. Plans include the construction of a dam and filtration plant, etc.

WACO—The Tulsa-Pittsburg Mining Co., Pittsburg, Kan., plans to move its mill from Diamond and erect same at Waco, and is in the market for boilers, hoist, pumps, rock drills and tables. Estimated cost, $75,000. A. O'Connor, superintendent.

WEBB CITY—Wommack & Co. plans to build a concentrating plant. Estimated cost, $60,000. E. Wommack, superintendent.

Montana

HELENA—The State Legislature has appropriated $50,000 for the construction of a laboratory here for the State Board of Health.

Nebraska

OMAHA—The Skinner Packing Co., 904 First National Bank Bldg., has awarded the contract for the construction of a 6-story, 65 x 65 ft. fertilizer factory, to Collins Bros., Omaha. Estimated cost, $50,000.

OMAHA—The State Legislature, Lincoln, plans to appropriate $40,000 for installing electrical apparatus, laboratory equipment, etc., in the University of Nebraska, College of Medicine, at 42nd St. and Dewey Ave. J. Latenser, 632 Bee Building, architect.

New Jersey

HARRISON—Berkowitz Bros. are having plans prepared by M. J. Nadel, architect, 15 Clinton St., Newark, for the construction of a candle factory on Plane St. Estimated cost, $50,000.

NEWARK—The Miller & Moran Chemical Works, Meadow St. near Lincoln Highway, plans to rebuild its plant, recently destroyed by fire, entailing a loss of $25,000.

New York

BROOKLYN—J. Bene & Sons, 641 Dean St., has had revised plans prepared by M. Freehof, architect, 405 Lexington Ave., New York City, for a 1-story, 100 x 100 ft. chemical factory on Clinton Ave. near Fulton St. Estimated cost, $35,000. Noted Dec. 30.

BROOKLYN—The Beth Moses Hospital, Hart St. and Stuyvesant Ave., will install a laboratory in the 5-story, 90 x 100 ft. addition to the hospital which it plans to build. Total estimated cost, $350,000. H. J. Nurick, 957 Broadway, architect.

CANASTOTA—The city plans election soon to vote on proposition to install sterilization plant.

MIDDLEPORT—The Board of Trustees plans to install a filtration plant and equipment, using the water from the Barge Canal. Estimated cost, $20,000.

OLEAN—J. J. Mahoney, supervisor of health of Cattaraugus and Chautauqua Counties, has petitioned the State Board of Health, Albany, for the construction of a pathological laboratory here.

OLEAN—The United States Glue Co. plans to build a 1-story and 2-story glue manufacturing plant. Estimated cost, $300,000.

UTICA—E. Kemper, city engineer, has completed plans for the construction of a sewage disposal plant to be located in the Sixteenth Ward.

UTICA—The State Hospital Commission, Capitol, Albany, has awarded the contract for the construction of a 2-story, 44 x 60 ft. laboratory and mortuary at the State Hospital, here, to Laporte & Goodman, P. O. Box 284, Albany, $23,900. Noted Feb. 15.

WATERTOWN—The city is having surveys made and plans prepared by E. W. Sayles, city engineer, for the construction of a sewage disposal plant in the Eighth Ward.

WATERTOWN—The Water Board plans to equip a purification and pumping station with apparatus for making water analysis and alum tests. J. W. Phippen, superintendent.

WILLARD—The New York State Hospital Commission, Capitol, Albany, will receive bids until April 9 for the construction of a chlorinating plant at the Willard State Hospital here. F. L. Warne, steward, L. F. Pilcher, state architect. Noted March 15.

Ohio

FINDLAY—The State Board of Health, Columbus, has ordered the city to build a sewage treatment plant. U. K. Stringfellow, city engineer.

FREMONT—The city plans to build a filtration plant. Estimated cost, $90,000. G. W. Lesher, city engineer.

NORWALK—The State Board of Health has ordered the city to build a sewage disposal plant. C. W. Anderson, mayor.

PAULDING—The city plans to purchase chemical equipment for the local fire department.

TOLEDO—F. S. Royster Guano Co., 813 Second National Bank Bldg., plans to build a sulphuric acid plant on a 5-acre site adjoining its fertilizer factor on Stickney Ave. Estimated cost, $500,000.

TOLEDO—The Standard Oil Co. of Ohio, Gas Bldg., Cleveland, has purchased a site of 810 acres northeast of the city and is having plans prepared for the construction of twenty-four crude oil stills, twelve running stills, eighty pressure stills, and from twelve to twenty-four other stills, steel storage tanks, warehouses, etc. Estimated cost, between $4,000,000 and $5,000,000.

WAUSEON—The city plans an election about May 1 to vote on a $170,000 bond issue for the construction of a filtration plant, pipe lines and an 80,000,000-gal. capacity impounding reservoir. W. J. Sherman, 613 Nasby Bldg., Toledo, engineer.

Oklahoma

BURKBURNETT—The Interstate Refining Co., recently organized, plans to build an oil refinery here, having a capacity of 1500 bbl. J. A. Jones, president.

PICHER—The Beck Mining Co. plans to move its mill from Quapaw field and erect same at Picher, and is in the market for hoists, rock drills, tubs and ground cars. Estimated cost, $75,000. A. Beck, general manager.

Oregon

GASCO—The Portland Gas & Coke Co., Gasco Building, Portland, has awarded the contract for the construction of an extension to its gas plant here, to O. R. Wayman, 939 Thurman St., Portland. Estimated cost, $15,000.

PORTLAND—The Pfister & Vogel Leather Co., 443 Virginia St., plans to build a 7-story, 100 x 125 ft. addition to its tannery. Estimated cost, $125,000. C. P. Bossert, engineer, care of company, is receiving bids.

Texas

BIRDVILLE—The Ok-In Producing & Refining Co. plans to build an oil refinery here, having a daily capacity of 5000 bbl. Estimated cost, $250,000. G. W. Merrill, Ft. Worth, president.

BURKBURNETT—The Meridian Gasoline Co. plans to build a casinghead gasoline plant. W. K. Campbell, president.

EL PASO—The El Paso County Medical Society plans to build a 6-story office building at Mesa Ave. and Franklin St. Plans include the installation of community laboratories, operating rooms, etc.

FT. WORTH—The Eldorado Refining Co., Eldorado, Kan., plans to build an oil refinery here, having a daily capacity of 5000 barrels.

FT. WORTH—The Home Oil & Refining Co., recently incorporated with $5,000,000 capital, has awarded the contract for the construction of a refinery, to W. C. Hedrick Construction Co., Ft. Worth National Bank Bldg. W. M. Babcock, 1119 North Main St., Tulsa, Okla., president.

FT. WORTH—The Texas Producing & Refining Co., recently incorporated with $2,000,000 capital, plans to build an oil refinery. W. H. Newberry, Childress, and J. Gee, Ft. Worth, interested.

HOUSTON—The Humble Oil & Refining Co., 1019 Main St., plans to build a 10,000-bbl. lubricating oil plant on the ship channel near here. Estimated cost, $2,000,000.

WICHITA FALLS—The New-Tex Refining Co. plans to build an oil refinery, having a capacity of 2000 bbl. E. B. Bailey, president.

Utah

SALT LAKE—The General Reduction & Chemical Co., 23 West 2nd St., plans to build a plant for the manufacture of sulphuric, nitric, hydrochloric and other acids. Estimated cost, $250,000.

Wisconsin

BUTTE DES MORTS—The Peerless Paper Products Co., Menasha, has purchased a site on Little Lake, near here, and plans to build a new pump and paper mill. Estimated cost, $100,000. T. E. McGillan, general manager.

GREEN BAY—The Ft. Howard Paper Mill, recently organized, plans to build a paper mill. Estimated cost, $200,000. A. Cafvin, manager.

MENASHA—The Peerless Paper Products Co., Manitowoc St., is having plans prepared by L. A. De Guere, engineer, Wood County Bank Bldg., Grand Rapids, for the construction of a 3-story, 40 x 150 ft. paper mill.

SHEBOYGAN—The American Hide Co., 1102 Wisconsin Ave., has awarded the contract for the construction of a 4-story tannery on South Water and Wisconsin Ave., to Morris Shukdart. Estimated cost, $8750.

SHEBOYGAN—Juul & Smith, architects, 805 North 8th St., will receive bids until April 15, for the construction of a 4-story, 100 x 250 ft. tannery on Illinois and Water St., for the Badger State Tannery Co. Estimated cost, $45,000.

Ontario

GUELPH—James, Loudon & Hertzberg, engineers, Excelsior Life Bldg., Toronto, will receive bids in about five weeks for the construction of a 4-story, 80 x 200 ft. factory on Metcalf St., for the Premier Rubber Co. Estimated cost, $135,000.

KITCHENER—The Kaufman Rubber Co., 419 King St., plans to build an addition to its plant. Estimated cost, $40,000. A. R. Kaufman, manager.

OTTAWA—The Y. M. C. A., Metcalfe St., plans to build a mechanical filtration plant to filter 30,000 gal. of water for a swimming tank. G. Crain, president.

ROCKLAND—W. C. Edwards & Co., Ltd., Sussex St., Ottawa, will soon receive bids for the construction of a pulp and paper mill here. Estimated cost, $3,600,000.

Quebec

THREE RIVERS — The International Paper Co., 30 Broad St., New York City, N. Y., plans to build a 1- and 2-story paper plant here. Estimated cost, $3,000,000.

Saskatchewan

REGINA—The Continental Oil Co. plans to build an oil refinery here. Estimated cost, $1,000,000. A. B. Allen, local manager.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold a meeting at 29 S. LaSalle St., Chicago, May 13 and 14.

THE AMERICAN CHEMICAL SOCIETY will hold a meeting in Buffalo, April 7 to 11.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its annual meeting in New York City from April 3 to 5.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its 22nd annual meeting at Atlantic City, N. J., June 24-27. The headquarters will be at the Hotel Traymore.

THE AMERICAN ZINC INSTITUTE will hold its annual meeting at St. Louis, Mo., May 12.

THE NATIONAL FOREIGN TRADE COUNCIL will hold its sixth National Foreign Trade Council at the Congress Hotel, Chicago, Ill., on Thursday, Friday and Saturday, April 24, 25 and 26, 1919.

THE NATIONAL SERVICE COMMITTEE of the Engineering Council will hold a meeting at Chicago, Ill., April 23 to 25.

THE NEW JERSEY CHEMICAL SOCIETY will hold a meeting in Newark on April 7.

Industrial Notes

THE COMMONWEALTH SILICA CO., Ottawa, Ill., producer of sand for iron and steel manufacturing purposes, has recently purchased the property of the Ottawa Steel Molding Sand Co., which has 84 acres of "Buffalo Rock" land and all equipments.

THE COE-STAPLEY MFG. CO., formerly at 135 Broadway, New York, is now located at 136 Liberty Street.

THE TOLLAND MFG. CO., Montreal, Can., has recently placed on the market a metal known as "Tamco," which is particularly adapted for rolling mill and all other bearings subject to heavy pressure.

THE OHIO METAL BRIQUETTING CO., Cleveland, Ohio, has placed a contract with the Crowell-Lundoff-Little Co. for a new plant for manufacturing briquets of scrap metal. Annealing furnaces and some other equipment will be required.

THE COMMERCIAL AND INDUSTRIAL BUREAU OF THE POLISH NATIONAL DEPARTMENT has been organized for the purpose of re-establishing commercial relations between the United States and Poland. It will collect all data and information to form a basis for the work of the future official Polish agencies in this country. The Bureau will be glad to furnish information concerning trade conditions and business opportunities in Poland and will also direct individuals and organizations desirous of getting in contact with the Polish market. The Bureau is established at 1032 Aeolian Building, 33 West 42nd St., New York City.

THE NATIONAL ANILINE & CHEMICAL CO., INC., New York, N. Y., announces a new product of its factories in Niagara Blue B R. It is identical with Diamine Blue B X and Benzo Blue B X, which were formerly imported. These prototypes were some of the most widely used brands of Direct Blue, and were put to many special uses.

THE WRIGHT CHEMICAL CORPORATION is enlarging its plant for the manufacture of dyes, intermediates and other chemicals, among which are sulphur colors, dinitrophenol, dinitrochlorbenzol, indophenol, para amidophenol base, para amidophenol and hydrochloride. Mr. A. A. Matheson, who recently resigned as general manager of the Union Dye & Chemical Corp., Kingsport, Tenn., has been elected president of the Wright concern, succeeding Mr. E. J. Wright, who is now vice-president. Mr. A. E. Crocker continues as treasurer. The plant of the Wright Chemical Corp. is at Springfield, N. J., and the office at 38 Park Row, N. Y. C.

TATE-JONES & CO., INC., furnace engineers, Pittsburgh, Pa., announced that after Feb. 1, 1919, Mr. Edward S. Davis will act as district manager, directing sales and service in the Chicago district, with offices located at 931 Monadnock Bldg., Chicago, Ill. Mr. Davis has returned to the company after six months of service as chief, Fuel Oil Section, Bureau of Oil Conservation, United States Fuel Administration.

SCHAEFFER & BUDENBERG, Brooklyn, N. Y., announce the establishment of a selling office at Tulsa, Okla. Mr. T. C. Eales has been appointed as district manager.

FREYN BRASSERT & CO., engineers, Peoples Gas Bldg., Chicago, Ill., announce the appointment of Mr. Wyman Eaton as chief engineer, taking effect Feb. 15, 1919. Mr. Eaton recently resigned as engineer in charge of rolling mill work of the Mesta Machine Co. to take up his new duties.

WALLACE & TIERNAN CO., INC., 349 Broadway, New York City, manufacturers of W & T chlorinating apparatus, have recently appointed Mr. David Morey, Jr., Southwestern representative. Mr. Morey is located at 507 Scollard Bldg., Dallas, Texas.

WARREN WEBSTER & CO., Camden, N. J., announce the opening of a Texas office at 805 Sumpter Bldg., Dallas, Texas, with Mr. W. B. Irwin in charge as district representative.

EPPING-CARPENTER PUMP CO., Pittsburgh, Pa., announce that Mr. Theodore R. Hermanson, formerly of the Harrison Works of the Worthington Pump & Machinery Corp., has become associated with them as works manager.

WESTINGHOUSE CHURCH KERR & CO., INC., announce the opening of an office in the Western Indemnity Bldg., Dallas, Texas, in charge of Mr. A. W. Nichols.

THE NEW JERSEY ZINC CO., New York, had Mr. C. A. Stedman invite a score of the business press representatives to look over its building at 160 Fulton St. Excellent views of their operations were illustrated by motion pictures, after which the applications of zinc were shown. Hinges, doorknobs, doors, electric lamps, wastebaskets, desk sets, ornamental castings and innumerable articles of practical use were shown. All agreed that zinc takes a more beautiful metal finish than brass or bronze. No doubt manufacturers expecting to establish Asiatic trade will do well to promote zinc ware there, as those who like the silvery moon finish will be delighted with zinc products.

THE ELYRIA ENAMELED PRODUCTS CO., Elyria, Ohio, has recently added to its technical force Mr. William H. Jackson, who will serve as engineering assistant to the plant superintendent, and Mr. Max Donauer, who will co-operate with the sales and chemical departments in the application of glass enameled equipment to the chemical industry.

ARTHUR D. LITTLE, INC., Cambridge, Mass., announces that Mr. Herbert L. Sherman, formerly president of the New England Bureau of Tests, Inc., and more recently in charge of inspection for the Construction Division of the United States Army, has joined the corporation, and will be in charge of the department for the testing and inspection of structural materials.

SILL & SILL, 1011 Figueroa St., Los Angeles, Calif., are equipping new offices at the foregoing address and installing complete laboratory equipment for ore testing.

THE CHICAGO PNEUMATIC TOOL CO., Chicago, Ill., has opened offices and warehouses at Tulsa, Okla. and El Dorado, Kansas. The Boston office has recently been removed to 182 High St., in charge of Mr. F. S. Eggleston, district manager of sales. The Detroit office has been moved from 236 Hancock Ave. to 502 Farwell Bldg. The following changes in the staff are announced: Mr. J. I. Edwards has been appointed as manager rock drill sales division, succeeding Mr. E. Eklund, who has been appointed special foreign representative. Mr. Fred H. Waldron, formerly Minneapolis representative, has been appointed

manager pneumatic tool sales division, succeeding Mr. J. G. Osgood, resigned. Mr. Nelson B. Gatch has been made district manager of sales at Minneapolis, with offices at 301 Metropolitan Bank Bldg. Mr. J. K. Haigh has been made assistant district manager of sales in the San Francisco office at 175 First Street.

PAUL O. ABBE, INC., is the title of the new organization created to succeed the business of Paul O. Abbe. The new corporation has purchased a site on which new buildings are being erected to afford increased manufacturing facilities. Mr. Henry Selman, one of the original inventors and developers of the grinding mill, is associated with the new corporation.

THE ELECTRIC FURNACE CONSTRUCTION CO.'s president, Mr. Frank Hodson, returned from Europe Feb. 24, accompanied by Mr. Mr. Harry Etchells, one of the inventors of the "Greaves-Etchells" furnace. Mr. Etchells, during his short stay in America, is to act in an advisory capacity on the latest European practice.

THE AMERICAN STEAM CONVEYOR CORP., Chicago, Ill., announces the appointment of Mr. C. E. Hague as sales manager. Mr. Hague was formerly production engineer of the Mid-West Engine Co., Indianapolis, Ind.

MURPHY & BREWSTER, 40 Cedar St., New York City, announce that Mr. John D. Lyman, formerly sales manager of the Edison International Corp., has been associated with them since March 1, 1919.

THE ELECTRIC FURNACE CO., Alliance, Ohio, has under construction ten Baily electric brass furnaces at the Salem plant to fill a Mexican contract and other similar domestic and foreign orders. This company has just closed a contract to ship to Mexico complete Baily electric furnace equipment for melting brass. The furnaces are of the tilting type, and are rated at 105 kw. electrical capacity, 1500 lb. hearth capacity and a melting rate of 600 lb. per hour.

THE PULVERIZED FUEL EQUIPMENT CORP. has recently been organized for the purpose of taking over the business of the Locomotive Pulverized Fuel Co., and to broaden the activities of the latter to cover the central power station, metallurgical and industrial fields. The head offices are at 30 Church Street, New York City, with a Canadian office in the Transportation Bldg., Montreal. The officers of the Pulverized Fuel Equipment Corp. will be J. S. Coffin, chairman; J. E. Muhlfeld, president; H. F. Ball, vice-president executive, H. D. Savage, vice-president in charge of sales; V. Z. Caracristi, vice-president in charge of engineering, and Samuel G. Allen, secretary-treasurer.

THE ELECTRICAL STEEL CO. OF INDIANA, Indianapolis, Ind., recently completed the addition to its foundry immediately adjacent to the Heroult electric furnace to house a chemical laboratory. The addition consists of a detached 1-story building, and is fully equipped with complete chemical apparatus for the analysis of melting stocks and alloys and for the determination of preliminary and final tests of the product of high-grade electric steel castings. In addition to providing for accurate chemical control arrangements have been made for photographic work.

Manufacturers' Catalogs

W. S. ROCKWELL CO., 50 Church Street, New York, calls attention to Bull. No. 39 on rotary annealing and heat-treating furnaces. The design of the furnace is that of a rotating horizontal cylinder with a refractory or metallic spiral lining, so that when material is charged in bulk into the charging drum at one end it is gradually and automatically conveyed through numerous convolutions and at gradually increasing temperature to the other end, where it is automatically discharged at the exact time that it reaches its required temperature. A concentric hood serves to automatically close the discharge opening except at the lowest point of revolution and time of discharge. The hood also serves to guide the material as it leaves the furnace. The furnace is intended to handle, either for annealing, hardening, tempering, blueing or other heat treatment, any small pieces of like dimensions in either brass, copper, steel or other metals, such as cartridge shells, eyelets, ferrules, buttons, caps, cups, coin blanks, steel balls, saw teeth, tacks, screws, rivets, rings, springs, nuts, punchings, etc.; in fact, any small pieces which will travel freely and pass through the openings without choking them. A table on page 13 shows that the fuel consumption in this rotary furnace is very low indeed, averaging about 250 pounds of heat-treated material to a gallon of oil. The labor cost is also low. A novel heat-treatment chart is shown on page 15. Copies will gladly be sent upon request.

THE DENVER FIRE CLAY CO., Denver, Colo., has issued a pamphlet on its technical service relating to furnaces, refractories, laboratory equipment and chemicals. Bulletin 325, on "China Kilns," is another booklet which has just been issued by this company.

SCHAEFFER & BUDENBERG, Brooklyn, N. Y., illustrates and describes its Columbia recording thermometers in Catalog No. 300, just off the press. This attractive catalog is well illustrated, showing actual installations.

THE BLAW-KNOX CO., Pittsburgh, Pa., calls attention to folders, entitled "Build Your Road With Blawforms," "Blawforms for Road, Sidewalk, Curb, and Curb and Gutter Construction," and also a booklet entitled "Products of the Blaw-Knox Co."

THE JEFFREY MANUFACTURING CO., Columbus, Ohio, has issued a descriptive Catalog, No. 210, on the Jeffrey pivoted bucket carrier, for handling coal, ashes, clinker, etc. The catalog is divided equally in its 96 pages between convincing and keenly illustrated details of the carrier, many interesting exterior and interior pages of large power plant equipments and also reproductions of dimensioned blue prints in actual color of typical views for the various sizes of carrier equipment which should be of interest to the architect and engineer. This company has also gotten out Catalog No. 245, on the Jeffrey type-A shredder, which illustrates and describes in 24 pages its swing hammer shredder. Copies will gladly be sent upon request.

THE STEERE ENGINEERING CO., Detroit, Mich., has issued Bull. No. 37, on gas purification, covering the removal of carbonic acid, hydrogen-sulphide, carbon disulphide, ammonia and cyanamide. The bulletin describes methods of purification with lime and iron oxide.

THE SWENSON EVAPORATOR CO., Chicago, Ill., has prepared a pamphlet on the making of maltose, malt syrups and malt extract with special reference to the conversion of breweries to the manufacture of these materials. The pamphlet describes Swenson equipment suitable for this purpose.

THE DURIRON CASTINGS CO., New York, N. Y., has just published Bull. 103, describing Duriron denitrating towers. The pamphlet consists not only of a description of the denitrating and oxidizing system manufactured by the company, but also a brief treatise on the general principles of denitrating spent acid from nitration processes.

THE NICU STEEL CORP., LTD., Box 128, Welland, Ont., Canada, has received from the press its booklet entitled "Nicu Steel," which is a high-grade alloyed steel able to stand hard usage and rough treatment, viz.: Transmission shafts and gears, crank shafts, axles, springs, valve stems, rods, etc. This company has a New York office at 43 Exchange Place.

THE QUIGLEY FURNACE SPECIALTIES CO., INC., New York City, illustrates and describes in Bull. No. 11 the Quigley powdered fuel system for preparing, distributing and burning powdered fuel.

THE J. D. FATE CO., Plymouth, Ohio, has just issued two bulletins on gasoline locomotives. These bulletins show the locomotive in use in various companies.

THE WALTER A. ZELNICKER SUPPLY CO., St. Louis, Mo., announces that its Bull. No. 260, on steel sheet piling, is ready for distribution.

THE AIR REDUCTION CO., INC., 120 Broadway, N. Y., has issued folders which show the benefits derived from the use of Airco products and methods, both for the purpose of building up worn frogs and repairing damaged locomotive cylinders.

ADAM HILGER, LTD., 75A Camden Road, London, N. W. 1, England, calls attention to an attractive booklet on Abbe refractometer with water jacketed prisms, and also a booklet on the Hilger wavelength spectrometer (constant deviation type) and the Nutting photometer.

THE SCIENTIFIC MATERIALS CO., Pittsburgh, Pa., recently issued a pamphlet on American Medical museum jars, which it designed and patented.

THE DEISTER CONCENTRATOR CO., Fort Wayne, Ind., has issued a special bulletin dealing with the No. 7 diagonal deck coal washing table.

THE HENDRICK MANUFACTURING CO., Carbondale, Penn., has just received from the press an attractive 128-page catalog entitled "Perforated Metals." It illustrates the various designs of screen plates, manufactured screens, elevator buckets, conveyor trough and flights, and general sheet and light structural work.

THE LAWRENCE PUMP & ENGINE CO., Lawrence, Mass.: Catalog "C" illustrates and describes centrifugal pumps.

THE GRISCOM-RUSSELL CO., 90 West St., New York, calls attention to Bull. 609, on Reilly multiscreen feed water filter and grease extractor.

THE LEEDS & NORTHRUP CO., Philadelphia, Pa., has just issued a new bulletin entitled "Checking Thermocouple Pyrometers." It discusses the importance of maintaining standards and of checking in pyrometry. It points out sources of error and the remedies for troubles in thermocouples, millivoltmeters, cold junctions and potentiometers. It outlines a commercial checking laboratory, including a special checking furnace, precision potentiometers and standardized thermocouples.

Stocks and Bonds

Closing Bid and Asked Quotations February 27, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am.Ag.Ch.	103¼	103½	Mat.Al.Wk.	131	44
do.pf.	99	100	Ten. C. & C.	2½	13
Barrett Co.	120½	121	Un. Dyewood.	55	61
do.pf.	113¾	117½	do. pf.	90	95
Gen.Chem.	170	180	Va.-Car. Ch.	56½	57
do.pf.	102	104	do. pf.	111	114
Int.Ag.Ch.	16	18			
do. pf.	65	66			

Bonds

	Bid	Ask
Am. Ag. Ch., 1st cv. 5s, '28	97½	99¾
Am. Ag. Ch., cv. db. 5s, '24	104	105¼
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32	81½	81¾
Va.-Car. Ch., 1 mtg. 5s, '23	95½	96
Va.-Car. Ch., cv. db. 6s, '24	101	101½

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co.	72½	73½	P-A Pet & Tr.	78¾	79½
Cal. Pet.	25¾	26¼	do. pf.	134	139
do. pf.	68¾	69¾	Pierce Oil	18½	18¾
Col. G. & E.	44¾	45	Royal Dutch	92¼	93
Mex. Pet.	180¾	181	Sinclair O & R	45¼	46
do. pf.	105	109	Texas Co.	208½	209
Ohio Cit. Gas.	38¾	38¾	Tex. Pac. Ld. Tr.	260	300
do. pf.	....	....	Tidewater Oil	210	220
Ohio Fuel S.	45½	46½			
Okla. P. & R.	8¾	8½			

Bonds

	Bid	Ask
Columbia Gas & Electric, 1 5s, '27	84¾	85
Col. G. & El., std. 1 5s, '27	84¾	....
Pan-Am. Pet. & Tr. 1 6s, '19-'27	125	....
Pierce Oil, cv. db. 6s, '24	94½	94¾
Pierce Oil, cv. 5% Notes, '20	102	103¾
Sin. O. & R. 1 In. 7s, '20, with stk. war.	103½	103¾
Sin. O. & R. 1 In. 7s, '20 without stk. war.	96¼	96¾
Texas Co., db. 6s, '31	102¾	103
Union Oil of Cal. 1 5s, '31	93	94
United Fuel Gas 1 mtg. 6s, ser. A, '36	96	97

IRON AND STEEL SECURITIES

	Bid	Ask		Bid	Ask
Am. St. F.	81	82	Pitts.Ste. pf.	91	95
Beth. Steel	65	66	Rep. Iron & Steel	81	81½
do. class B.	65¾	66	do. pf.	101½	103½
do. pf., 8%.	104¾	105			
do. pf., 7%.	91¾	99	Sloss Sheff. I. & S.	52	53
Central Fdry.	13	21	do. pf.	84	90
do. pf.	30½	34	Superior Steel.	36½	37
Col. F. & I.	41½	42	do. 1 pf.	96	98
do. pf.	105	115			
Cruc. Steel	65½	65¾	Trans. & W. Steel	40¾	41½
do. pf.	93¾	100			
Great No. Ore	40¾	41	Un. Alloy St.	42½	43
Gulf Sta. Steel	53	54	U.S.C.I.P.&F.	19	19½
do. 1 pf.	92	98	do. pf.	54	54½
Lack. Steel	69	69½	U. S. Steel	97½	97¾
Mid.St.& Ord.	45¾	45¾	do. pf.	114¾	115
Nova Scotia Steel	48½	50½	Va. Coal,I&C.	56	59

Bonds

	Bid	Ask
Beth. Steel, 1 ext. gtd. S.F. 5s, '26	96	96½
Beth. Steel, 1 In. ref. 5s, Ser. A, '42	88	88½
Beth. Steel, P. M. & I. S. F. 5s, '36	83½	84½
Buff. & Susq. Iron, 1 S. F. 5s, '32	91	96
Buff. & Susq. Iron, deb. 5s, '27	....	....
Cent. Found. 1 mtg. S. F. 6s, '21	78	82
Col. F. & I., gn. S. F. 5s, '43	90	92
Ill. Steel, db. 4½s, '40	83¾	85½
Ind. Steel, 1 mtg. gtd. 5s, '52	96	96½
Lack. Steel, 1 5s, '23	97	98
Lack. Ste., 1 con. mtg. cv. 5s, Ser. A, '50	89	90½
Mid. St. & Ord., clt. cv. S. F. 5s, '36	88	88½
Nat. Tube, 1 mtg. gtd. 5s, '52	94	95
Rep. I. & S., S. F. mtg. 5s, '40	95	95¾
Tenn. C. & I. R.R., gn. 5s, '51	92	93
U. S. Steel, S. F. 5s, '63	100	100½
Va. C., I. & C., 1 5s, '49	85¾	86